New Bedford Harbor 16

222672

EPA WORK ASSIGNMENT NUMBER: 04-1L43

EPA CONTRACT NUMBER: 68-01-7250

EBASCO SERVICES INCORPORATED

DRAFT FEASIBILITY STUDY

ESTUARY AND LOWER HARBOR/BAY

NEW BEDFORD HARBOR
MASSACHUSETTS

VOLUME II

APRIL 1990

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ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

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5.0 <u>IDENTIFICATION, SCREENING, AND EVALUATION OF TECHNOLOGIES</u>

5.1 INTRODUCTION

Remedial alternatives consist of combinations of technology types and process options necessary to achieve the remedial action objectives developed for a site. Technology types may include excavation/dredging; physical, chemical, thermal, and biological treatment; containment; and disposal. Several technology types may be identified for each response action. Specific technologies, or process options, may exist within each technology type. For example, physical treatment would include process options such as solvent extraction, solidification, and air-stripping. General response actions and technology types were identified for the New Bedford Harbor site and are shown in Figure 5-1.

This section discusses results of the identification, screening, and evaluation of technologies. It is an inventory of applicable technologies that can be assembled into remedial alternatives capable of meeting the remedial action objectives for the estuary and lower harbor/bay.

5.2 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

The PCB- and metals-contaminated sediment in the Acushnet River Estuary and New Bedford Harbor is the primary environmental medium of concern. Identification and screening of remedial technologies are the first steps in producing an inventory of applicable technologies for treating this sediment. Technology types and process options for remediating hazardous waste were identified through numerous sources, including trade periodicals, computer data base searches, EPA Superfund guidance documents and funded studies, other FSs, and direct contacts with technology vendors. Technology types and process options identified for treating New Bedford Harbor sediment are presented in Table 5-1. Technology types and process options were also identified for treating PCB- and metals-contaminated water generated as a liquid wastestream during sediment dewatering and treatment (see Table 5-1). In the subsequent screening step, technologies were eliminated from further consideration on the basis of technical implementability with respect to the site- and waste-specific conditions found in the Acushnet River Estuary, Lower New Bedford Harbor, and Buzzards Bay.

Figure 5-2 summarizes the technology types and process options retained for detailed evaluation. The identification and screening of technologies for the New Bedford Harbor site has been described in detail in numerous published reports (E.C.

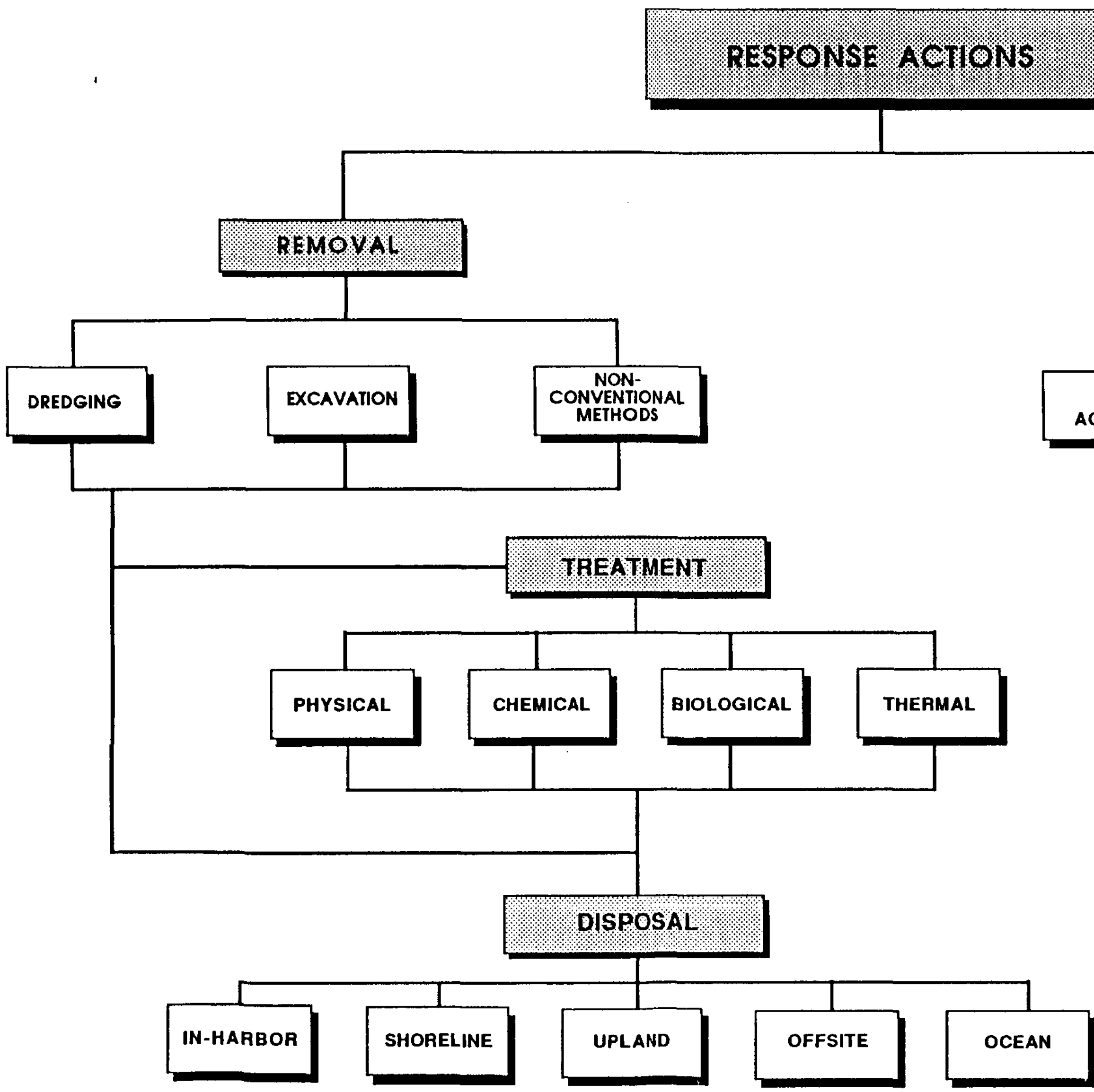

FIGURE 5-1
GENERAL RESPONSE ACTIONS & TECHNOLOGY TYPES
IDENTIFIED FOR NEW BEDFORD HARBOR
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR

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TABLE 5-1
TECHNOLOGY TYPES AND PROCESS OPTIONS
IDENTIFIED FOR NEW BEDFORD HARBOR
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
New Bedford Harbor, Massachusetts

Medium	Response Action	Technology Type	Process Options
Sediment	Removal	Dredging	
		Mechanical	Clamshell
			Watertight Clamshell
			Dragline
			Dipper
			Orange Peel
			Bucket-Loader
			Backhoe
			Sauerman
			Terra Marine
		Hydraulic	Plain Suction
			Dustpan
			Cutterhead
			Hopper
			Sidecasting
			Bucketwheel
		Special Purpose	Airlift
			PNEUMA
			Oozer
			Cleanup
			Refresher
			Waterless
			Drexhead
			Currituck
			Mudcat
			Hand Held

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TABLE 5-1 (Continued)
TECHNOLOGY TYPES AND PROCESS OPTIONS
IDENTIFIED FOR NEW BEDFORD HARBOR
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
New Bedford Harbor, Massachusetts

Medium	Response Action	Technology Type	Process Options
Sediment	Removal	Excavation	Dragline Clamshell Watertight Clamshell Scraper Dozers & Loaders Bucket Wheel Backhoe Gradall
		Non-Conventional	Sorbents and Gels Bioharvesting Oil Soaked Mats
	Non-Removal	Containment Capping	Clay/Sediment/Sand & Gravel Fabric Impermeable Synthetics Multimedia
		Hydraulic Controls	Dikes/Berms Sheet Piling
		In-Situ Treatment	Chemical Sealants In-situ Biodegradation
		No Action	-
	Treatment	Physical	Soil Aeration Evaporation Centrifugation Extraction Solidification/Stabilization In-situ Adsorption Molten Glass

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TABLE 5-1 (Continued)
TECHNOLOGY TYPES AND PROCESS OPTIONS
IDENTIFIED FOR NEW BEDFORD HARBOR
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
New Bedford Harbor, Massachusetts

Medium	Response Action	Technology Type	Process Options
Sediment	Treatment	Physical	Steam Stripping Liquified Gas Extraction Vitrification Particle Radiation Microwave Plasma Crystallization Dialysis/Electrodialysis Distillation Acid Leaching Catalysis
		Chemical	Alkali Metal Dechlorination Akaline Chlorination Catalytic Dehydrochlorination Electrolytic Oxidation Hydrolysis Chemical Immobilization Polymerization
		Thermal	Electric Reactors Fluidized Bed Reactors Fuel Blending Industrial Boilers Infrared Incineration In-situ Thermal Destruction Liquid Injection Incineration Molten Salt Multiple Hearth Incineration Plasma Arc Incineration Pyrolysis Processes Rotary Kiln Incineration Wet Air Oxidation Supercritical Water Oxidation

TABLE 5-1 (Continued)
TECHNOLOGY TYPES AND PROCESS OPTIONS
IDENTIFIED FOR NEW BEDFORD HARBOR
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
New Bedford Harbor, Massachusetts

Medium	Response Action	Technology Type	Process Options
Sediment	Treatment	Biological	Advanced Biological Methods Aerobic Biological Methods Anaerobic Biological Methods Composting Land Spreading
	Disposal	In-Harbor	Island Construction Confined Aquatic Disposal
		Shoreline	Confined Disposal Facility
		Upland	Lined Landfill
		Offsite	Permitted Disposal Facility
		Ocean	Sited Offshore Disposal
Water	Treatment	Physical	Carbon Adsorption Flocculation/Precipitation Ion Exchange Resin Adsorption Reverse Adsorption Ultrafiltration Granular Media Filtration
		Chemical	Neutralization Oxidation/Hydrogen Peroxide Ozonation Ultraviolet Photolysis

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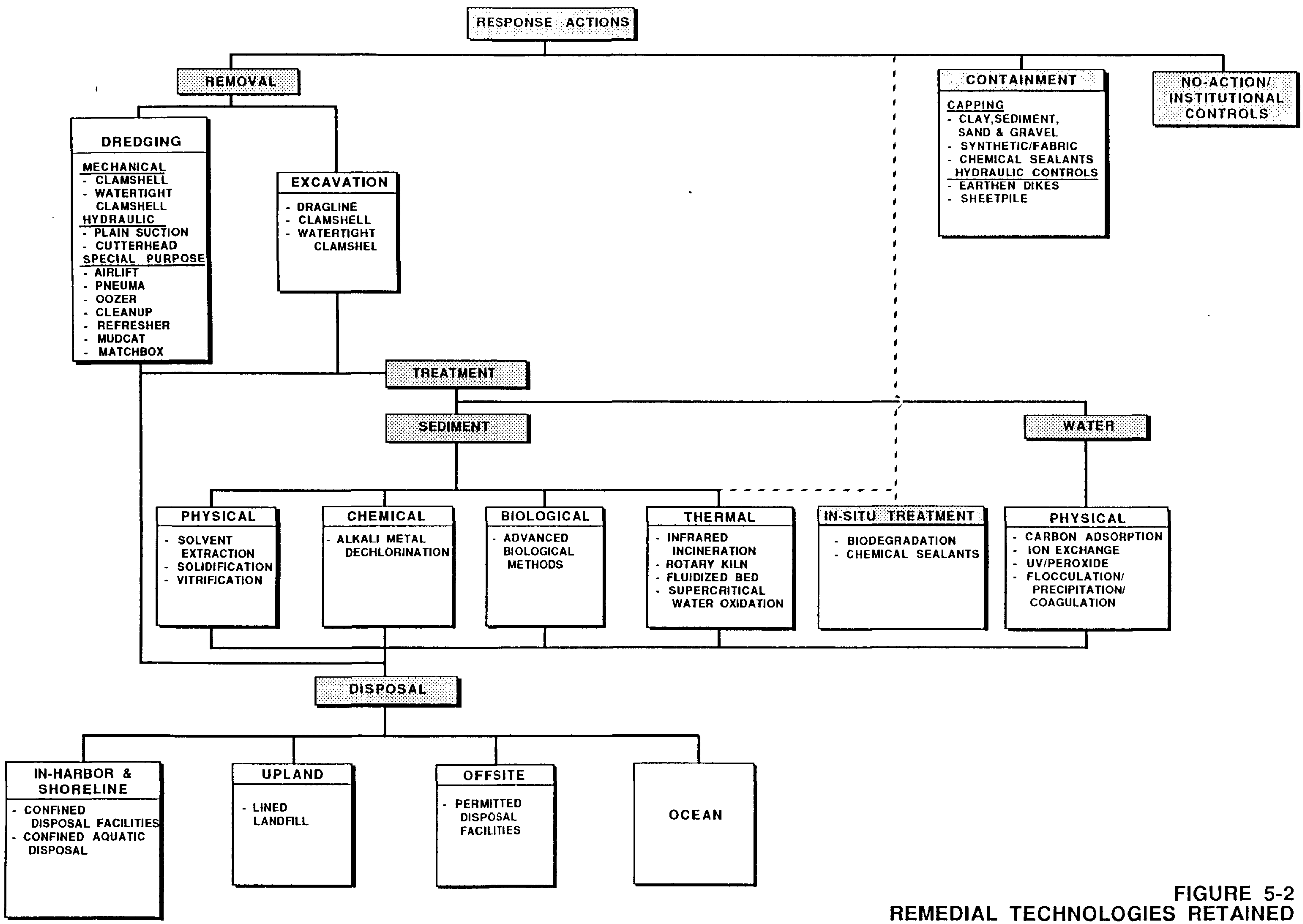

FIGURE 5-2
REMEDIAL TECHNOLOGIES RETAINED
FOR DETAILED EVALUATION
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR

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Jordan Co./Ebasco, 1987a, 1987b, and 1987c; and Palermo and Pankow, 1988).

5.3 DETAILED EVALUATION OF TECHNOLOGIES

The purpose of the detailed evaluation of technologies is to refine the list of applicable technologies retained after screening. One representative process is selected, if possible, for each technology type to simplify the subsequent development, screening, and detailed analysis of remedial alternatives without limiting flexibility during remedial design (see Sections 6.0 and 7.0). Selection of a specific representative process provides a basis for developing performance specifications during the preliminary design.

Process options for the New Bedford Harbor site were evaluated with respect to effectiveness, implementability, and cost; the same criteria used to screen alternatives prior to detailed analysis. However, these criteria were applied only to the technologies and not to the site as a whole.

The effectiveness of each technology was assessed on the basis of the potential effectiveness in handling the estimated area or mass of contaminated sediment and in meeting remedial objectives; the effectiveness in protecting public health and the environment during the construction and implementation phase; and the demonstrated level of development and reliability for the site- and waste-specific conditions in New Bedford Harbor.

Implementation of a technology considered factors relating to the technical, institutional, and administrative feasibility of installing, monitoring, and maintaining that technology. The cost estimates developed for each technology included direct and indirect capital costs, and operation and maintenance (O&M) expenses.

As part of the detailed evaluation of technologies for the New Bedford Harbor site, bench- and pilot-scale testing of treatment technologies, and pilot-scale testing of dredging and disposal options was conducted. Subsection 5.3.1 summarizes results of these tests. The individual process options and details of the evaluation process have been described in numerous published reports (E.C. Jordan Co./Ebasco, 1987c; and Palermo and Pankow, 1988).

5.3.1 <u>Dredging/Excavation</u>

Two types of technologies for sediment removal were evaluated for the New Bedford Harbor site: excavation and dredging. PCB- and metals-contaminated sediment and debris that cannot be removed by dredging may be excavated using land-based equipment operating from adjacent embankments. Of the three types of excavation equipment considered for detailed evaluation (i.e., dragline, clamshell, and watertight clamshell), only the watertight clamshell was retained. The watertight clamshell is a conventional crane equipped with a bucket having interlocking jaws that seal when closed to minimize leakage. Although these three excavation technologies are operationally similar, the major factor for retaining the watertight clamshell is that it produces the least amount of resuspended sediment (E.C. Jordan Co./Ebasco, 1987c).

Hydraulic barriers such as sheetpile walls might be used in conjunction with land-based excavation as a means of isolating contaminated areas before removal. Use of these barriers is discussed in Subsection 5.3.4.

Three types of dredges were evaluated for New Bedford Harbor: mechanical, hydraulic, and special purpose. Mechanical dredges are essentially cranes with grab buckets or clamshells, or even front-end loaders or backhoes mounted on a barge. Mechanical dredges were eliminated from further consideration during the evaluation process for three reasons (E.C. Jordan Co./Ebasco, 1987c): (1) use of mechanical dredges would be limited to localized areas in New Bedford Harbor where water depths exceed 6 feet (the minimum operating depth for barges and tugs); (2) activities associated with mechanical dredging (e.g., positioning of the barge by the tugs and transfer of contaminated sediment between the dredge barge and the hauling barge) would have potential for causing spillage and therefore sediment resuspension; and (3) limited horizontal and vertical accuracy of this type of dredge would result in overexcavation (i.e., approaching a factor of 6), causing an increase in sediment volume to be handled and the commensurate increase in disposal costs. In an independent analysis of dredging technologies, USACE confirmed the disadvantages of mechanical dredges when compared to hydraulic dredge types (Palermo and Pankow, 1988).

Of the three hydraulic dredges considered for detailed evaluation (i.e., cutterhead, hopper, and plain suction), only the cutterhead was retained in the Jordan/Ebasco study (E.C. Jordan Co./Ebasco, 1987c). The principal advantages of the cutterhead over the hopper and the plain-suction dredges include (1) greater operational flexibility throughout New Bedford Harbor (the size and draft of the hopper dredges would preclude operation in the estuary north of the Coggeshall Street Bridge); (2) better maneuverability near shorelines and wharfs; (3) less sensitivity to clogging than either the hopper or the plain-suction dredge; and (4) minimal sediment resuspension with proper operational controls.

USACE concurred with the selection of the cutterhead dredge in its independent analysis (Palermo and Pankow, 1988). In addition, USACE selected a second hydraulic dredge type (i.e., the matchbox) for further evaluation in its pilot dredging and disposal study. The matchbox dredge, originally developed in Holland for dredging contaminated sediment, is a plain-suction dredgehead enclosed in housing that resembles a matchbox. Tests of this dredge conducted by USACE in Calumet Harbor on Lake Michigan indicated that the matchbox, if properly operated, is capable of removing sediment with little resuspension.

Six special-purpose dredge technologies were retained by Jordan for detailed evaluation: airlift, pneuma, oozer, cleanup, refresher, and mudcat (E.C. Jordan Co./Ebasco, 1987c). These dredge technologies, employing special dredgeheads or modifications to conventional hydraulic dredges, are scaled-down versions of conventional dredging methods, or use compressed air as a method to dislodge and lift materials. An independent evaluation of several special-purpose dredge technologies was also conducted by USACE (Palermo and Pankow, 1988).

Of the six special-purpose dredges evaluated, the mudcat dredge (a horizontal auger dredge that is operationally a member of the hydraulic dredge family) was selected as the most versatile over the widest range of site conditions, based on minimal resuspension of material, production efficiency, and precision, accuracy, and control over the sediment-removal process (E.C. Jordan Co./Ebasco, 1987c). The mudcat dredge was also selected by USACE as the third dredge type to be evaluated in the pilot dredging and disposal study (Palermo and Pankow, 1988).

Two other special purpose dredges were identified by Jordan as having some application potential for New Bedford Harbor: the refresher dredge and the pneuma pump (E.C. Jordan Co./Ebasco, 1987c). The refresher dredge is a modification of the cutterhead dredge and is being developed in Japan. The pneuma pump, developed in Italy, uses a compressed-air chamber to remove sediment. Both dredges are capable of removing sediment with minimal resuspension and might be considered for removing sediment in small, localized areas and/or as back-up systems to the primary removal technologies selected for site work. However, USACE noted that both dredges were large draft vessels, and that the pneuma dredge does not operate well in shallow water (Palermo and Pankow, 1988). These factors would preclude them from operating in many portions of New Bedford Harbor. Furthermore, the availability of the refresher and pneuma dredges for work in New Bedford Harbor is questionable because of U.S. restrictions on the importation of foreign technology.

In summary, the cutterhead, matchbox, and mudcat dredges were retained as the three dredge types to be tested by USACE during its pilot dredging study. Results from this study were used in the selection of the best dredge type for dredging contaminated sediment in New Bedford Harbor.

5.3.1.1 U.S. Army Corps of Engineers Pilot Dredging Study

As an extension of the EFS for the Acushnet River Estuary, a pilot study of dredging and dredged material disposal methods was conducted by USACE from late 1988 through early 1989. The study site was a small cove located approximately 2,000 feet north of the Coggeshall Street Bridge on the New Bedford side of Acushnet River. The overall objective of this study was to evaluate different dredge types, dredge operating procedures, disposal methods, and control techniques. Results of the dredging portion of the pilot study are discussed herein. Results of the disposal methods portion of the pilot study are discussed in Subsection 5.3.3. A more detailed description of the pilot dredging study is presented elsewhere (USACE-NED, 1990).

The technical objectives of the pilot dredging study were to (1) determine the efficiency of dredging for the removal of PCB- and metals-contaminated sediment from New Bedford Harbor; (2) evaluate actual sediment resuspension and contaminant release under field conditions for each of the three dredge types; and (3) assess operational controls and turbidity containment techniques (Otis and Averett, 1988).

The three hydraulic dredges selected by USACE and Jordan (i.e., cutterhead, matchbox, and mudcat) were alternately used in the removal of approximately 3,000 cy (total) of contaminated sediment from two locations within the study area. In Dredge Location 1, the sediment PCB levels in the zero- to 6-inch horizon averaged 226 ppm. In Dredge Location 2, the PCB levels in the zero- to 6-inch horizon averaged 385 ppm (USACE-NED, 1990).

To assess the performance of the three dredges, USACE conducted a physical and chemical monitoring program during dredging operations. Data collected during this program were used to address the following (Otis and Averett, 1988):

- rate of sediment resuspension caused by the dredging operation
- rate of contaminant release, in particular PCB release, associated with each dredge
- contaminant flux in and out of the upper estuary during dredging
- efficiency of contaminant removal by the dredges

- dredging controls needed to minimize the rate of sediment resuspension at the dredge and measures that should be used to contain the suspended sediment plume near its point of generation

Concurrent with the USACE monitoring of dredging operations, an aquatic monitoring program was conducted to evaluate the effectiveness of dredging in terms of the extent of a suspended sediment plume, far-field water quality, and the associated effects on marine organisms. The aquatic monitoring program was conducted by USACE. The pilot study monitoring program also contained a biological component that was designed and carried out by EPA's ERL in Narragansett, Rhode Island. This component of the monitoring was carried out as an additional method of determining adverse impacts to water quality throughout the harbor that may have been associated with the dredging and disposal operations.

The biological tests used during the pilot study were developed by EPA ERL, and included the measurement of contaminants in tissues of the blue mussel, an acute and chronic toxicity test developed for the EPA Complex Effluent Toxicity Testing Program, and the scope for growth in mussels.

Pre-operational monitoring provided data on baseline contaminant concentrations in water and bioaccumulation in mussels, as well as biological effects on various organisms. These data were used to identify contaminant concentrations or biological responses that were "acceptable" in the context of existing conditions. These concentrations or responses were then compared to similar monitoring data collected during each operational phase of the project to detect statistically significant and/or biologically relevant changes. During the pilot study, no statistically significant or biologically relevant changes were detected. An overview of the monitoring program was described by Phelps (Phelps et al., 1988).

An air monitoring program for measuring levels of airborne PCBs was conducted by Ebasco as part of the dredging and disposal pilot study. Results from this program demonstrated that disposal of contaminated sediment in a shoreline CDF did raise the ambient air PCB levels above background. However, the increased levels did not threaten worker safety or public health, and were confined to the area immediately adjacent to the CDF. Preliminary results of the dredging pilot study are summarized in the following paragraphs.

<u>Sediment Resuspension</u>. A sediment resuspension rate of 40 grams per second (g/sec) was used in the contaminant release estimates contained in the conceptual dredging studies conducted by USACE (Averett, 1988). During the pilot dredging study, sediment

resuspension rates were empirically determined by sampling the water column immediately adjacent to the operating dredgehead for each of the three dredges. Data collected from these samples were combined with the dredge swing speed, rate of forward advance, and water depth to derive a resuspension rate.

Results indicated that the cutterhead dredge had the lowest resuspension rate, with an average of 12 g/sec over four days of operation. The matchbox dredge had an average of 48 g/sec over five days of operation. The mudcat dredge had the highest resuspension rate, with an average of 374 g/sec over four days of operation (USACE-NED, 1990). The significantly higher resuspension rate for the mudcat dredge is due to the sediment being removed by a rotating auger 9 feet in width. Sediment resuspension is occurring along the entire length of the auger, which channels sediment toward the center for removal (USACE-NED, 1990).

<u>Contaminant Release</u>. The standard elutriate test is used to estimate contaminant levels in the water column adjacent to the operating dredge. Results of the elutriate tests were combined with the sediment resuspension rate to obtain an estimate of the contaminant release rate at the dredge. Elutriate tests were conducted on sediment and water samples collected from two locations within the pilot study area. Results of these tests indicated that average total PCB concentrations in the water fraction were approximately 74 ppb (USACE-NED, 1990).

Composite samples were collected adjacent to the dredgehead during the pilot study. Mean total PCB concentrations of 7, 2.6, and 54.9 ppb were measured for the cutterhead, matchbox, and mudcat dredges, respectively (USACE-NED, 1990). Although the differences between the dredges were found to be statistically insignificant because of the wide variability in measurements, the mudcat dredge appears to be less effective in reducing sediment resuspension and contaminant release at the point of dredging (USACE-NED, 1990).

Results from the pilot study indicate that the elutriate test provides a conservative estimate of PCB concentrations in the water column during dredging and CAD filling operations. In general, PCB levels in the water column measured in the field were approximately one order of magnitude less than the elutriate test results.

Based on pilot study results, USACE prepared contaminant release estimates for dredging the contaminated sediment in the estuary and lower harbor/bay using a cutterhead dredge (USACE-NED, 1990). These estimates and the parameters used to derive them are presented in Tables 5-2 and 5-3 for the estuary and the lower harbor, respectively. USACE applied a safety factor of 2 to its estimates for the following reasons (Otis, 1990):

TABLE 5-2
CONTAMINANT RELEASE ESTIMATES DURING
DREDGING IN UPPER ESTUARY

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

PARAMETER DESCRIPTION	UNITS	PCB	CADMIUM	COPPER	LEAD
Dredge production rate, in situ sediment volume	cu m/hr	27			
Dredge slurry flow rate	cu m/hr	576			
Effective dredge operating time	hr/day	4			
Daily production rate	cu m/day	108			
Daily dredge slurry flow	cu m/day	2,300			
Dredge slurry TSS concentration	g/liter	40			
Solids pumping rate, dry weight	kg/day	92,160			
Sediment resuspension rate at dredge, TSS	g/sec	20			
Daily sediment resuspension rate at dredge, TSS	kg/day	288			
In situ sediment contaminant concentration	mg/kg	1,500	36	1,330	1,000
Elutriate contaminant concentration, whole water	mg/liter	0.18	0.0059	0.18	0.026
Elutriate dissolved contaminant concentration	mg/liter	0.11	0.0025	0.02	0.011
Elutriate TSS concentration	mg/liter	120	148	148	320

TABLE 5-2
(continued)
CONTAMINANT RELEASE ESTIMATES DURING
DREDGING IN UPPER ESTUARY

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

PARAMETER DESCRIPTION	UNITS	PCB	CADMIUM	COPPER	LEAD
Elutriate contaminant concentration on sediment	mg/kg	538	23	1,101	47
Elutriate dissolved contaminant concentration/ TSS	mg/kg	917	17	115	34
Contaminant flux at dredge with TSS	kg/day	0.17	0.007	0.32	0.014
Contaminant flux at dredge dissolved	kg/day	0.26	0.005	0.03	0.010
Total contaminant flux at dredge	kg/day	0.43	0.012	0.35	0.024
TSS escaping bridge (% fines=46, % escape=68)	Fraction	0.31	0.31	0.31	0.31
TSS escaping bridge	kg/day	89	89	89	89
Contaminant flux of bridge with TSS	kg/day	0.052	0.002	0.098	0.004
Contaminant flux at bridge, dissolved	kg/day	0.082	0.002	0.010	0.003
Total contaminant flux at bridge	kg/day	0.134	0.004	0.108	0.007
Contaminant flux at bridge with TSS (2x safety)	kg/day	0.104	0.004	0.196	0.008
Contaminant flux at dissolved (2x safety)	kg/day	0.164	0.004	0.020	0.006
Total contaminant flux at bridge (2x safety)	kg/day	0.268	0.008	0.216	0.014

NOTE: TSS = total dissolved solids

TABLE 5-3
CONTAMINANT RELEASE ESTIMATES DURING
DREDGING BELOW COGGESHALL STREET BRIDGE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

PARAMETER DESCRIPTION	UNITS	PCB
Dredge production rate, in situ sediment volume	cu m/hr	27
Dredge slurry flow rate	cu m/hr	576
Effective dredge operating time	hr/day	4
Daily production rate	cu m/day	108
Daily dredge slurry flow	cu m/day	2,300
Dredge slurry TSS concentration	g/liter	40
Solids pumping rate, dry	kg/day	92,160
Sediment resuspension rate at dredge, TSS	g/sec	20
Daily sediment resuspension rate at dredge, TSS	kg/day	288
In situ sediment contaminant concentration	mg/kg	98
Elutriate contaminant concentration whole water	mg/liter	0.08
Elutriate dissolved contaminant concentration	mg/liter	0.008
Elutriate TSS concentration	mg/liter	148
Elutriate contaminant concentration on sediment	mg/kg	487
Elutriate dissolved contaminant concentration/TSS	mg/kg	54
Contaminant flux of dredge with TSS	kg/day	0.14
Contaminant flux at dredge dissolved	kg/day	0.02

TABLE 5-3
(continued)
CONTAINANT RELEASE ESTIMATES DURING
DREDGING BELOW COGGESHALL STREET BRIDGE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

PARAMETER DESCRIPTION	UNITS	PCB
Total contaminant flux at dredge	kg/day	0.16
Total contaminant flux of dredge (2x safety)	kg/day	0.3

NOTES:
Results of the modified elutriate formed on sediment from the pilot study cove were used in making these contaminant release estimates.

TSS = total suspended solids

- The pilot study demonstrated that the USACE procedure for estimating contaminant releases was conservative for the sediment dredged during the pilot study. However, extrapolating results to the entire estuary and harbor should include consideration for the variability within the system and should be performed with caution.

- The release estimates are based on resuspension at the dredgehead and do not include other contaminant releases associated with work boats or moving anchors, which contributed additional contaminant loads.

- Estuary and lower harbor/bay sediments may contain pockets of oily material that may be freely released when disturbed by dredging.

- Sediment resuspension estimates and laboratory elutriate concentrations are average values. Above-average values will be encountered frequently.

The contaminant release estimates presented in Table 5-2 for dredging in the estuary indicate that a 4-hour-per-day operating cycle with a production rate of 27 cubic meters (i.e., 35 cy) per hour would generate a total (i.e., total suspended solids [TSS] plus dissolved) PCB flux of 0.43 kg/day at the dredge. The total PCB flux (with the safety factor of 2 applied and the estimate rounded to one significant figure) at the Coggeshall Street Bridge would be 0.3 kg/day.

For similar dredge operating conditions in the lower harbor, Table 5-3 indicates that a total PCB flux of 0.16 kg/day, or 0.3 kg/day with a safety factor of 2 applied, would be generated at the dredge. USACE used results of the modified elutriate test performed on sediment from the pilot study cove in developing these contaminant release rates.

<u>Contaminant Flux</u>. The EFS predicted that 76 percent of the mobile sediment fraction would escape during dredging in the vicinity of the cove, and 52 percent during dredging near the Hot Spot Area. Results from the dredge plume model indicated that an average (weighted by occurrence frequencies) of about 29 percent of the resuspended material will escape beyond the 100-yard radius of the dredging site. Results of this analysis were used with the contaminant release estimates at the dredge to estimate the flux of contaminants out of the upper estuary during dredging.

No elevated levels of suspended solids (above background) were measured at the Coggeshall Street Bridge (i.e., the southern boundary of the estuary) during dredging operations, except for one sampling event immediately following a storm. Pre-operational monitoring conducted for the pilot study indicated that background mean suspended solids concentrations at the Coggeshall Street Bridge ranged from 6.4 to 10.2 milligrams per liter (mg/L) (EPA, 1988). Suspended solids measured during the dredging operations with the cutterhead dredge, at sampling stations located approximately 300 feet from the dredge, ranged from 2 to 23 mg/L (USACE-NED, 1990).

Water column sampling was conducted during the pilot study at a sampling station located just east of the pilot study cove and at a sampling station located at the Coggeshall Street Bridge. The mean total PCB concentration measured during the pre-operational period was 0.60 ppb at the Coggeshall Street Bridge. The mean total PCB concentration measured during dredging operations was 0.77 ppb at the sampling station east of the cove, and 0.57 ppb at the Coggeshall Street Bridge (USACE-NED, 1990).

Efficiency of Contaminant Removal. All three hydraulic dredges used during the pilot study were able to remove contaminated sediment while minimizing sediment resuspension and overdredging. Only minor increases in suspended solids (above background) were measured at the near-field sampling stations located 100 yards from the dredgehead, with levels returning to the range of background conditions within 500 feet of the dredging operation. Sediment PCB levels after dredging were in the 10-ppm range, and generally less than 1.5 feet of sediment was removed.

Dredge Controls. Swing anchors are used on the cutterhead and matchbox dredges to allow the dredge to pivot laterally about its spud anchor. During the initial stages of the pilot study operations, these anchors frequently slipped in the soft bottom sediment, resulting in a plume of suspended sediment. Small boats used to set the anchors also stirred up bottom sediment, compounding the problem. USACE recommended setting the swing anchors on land.

Silt curtains, designed to prevent migration of a suspended sediment plume, do not appear to be justified because monitoring did not detect a significant sediment plume moving away from the dredge. In fact, installation, movement, and removal of the silt curtain in the shallow water conditions of the estuary caused a considerable amount of sediment resuspension. This would negate any beneficial effects of using a silt curtain.

5.3.1.2 Summary

Based on results of the pilot study, USACE concluded that all three dredge types were effective in removing contaminated sediment with a mimimum of sediment resuspension and contaminant migration. However, USACE recommended the cutterhead dredge for use in New Bedford Harbor, including the Hot Spot Area. The cutterhead dredge exhibited advantages over the matchbox and the mudcat in the following areas (USACE-NED, 1990):

- Dredgehead sampling indicated that sediment resuspension at the point of dredging was minimized with the cutterhead.

- Downtime due to clogging of the suction line with sediment and debris was less of a problem with the cutterhead.

- Worker exposure to contaminated sediment was minimized when clearing the clogged suction line.

- Dredging operations were not affected by windy conditions, which were a problem with the mudcat.

- Dredge movement and repositioning was more efficient, compared to the mudcat.

Operational procedures developed for the cutterhead dredge during the pilot study will help to ensure efficient removal of contaminated sediment with minimal sediment resuspension and contaminant release. Monitoring of suspended solids and PCB levels indicates that movement of contaminants away from the point of dredging is likely to be minimal. No elevated levels above background of suspended sediment or PCBs were detected at the Coggeshall Street Bridge during dredging operations.

5.3.2 Treatment

Ten sediment and four water treatment technologies were retained from the initial screening process for detailed evaluation (see Table 5-1). In evaluating those factors associated with implementing a treatment technology, demonstrated performance on a bench-, pilot-, or full-scale was used as a key indicator of the level of development and, therefore, the ability of a given technology to be implemented at the New Bedford Harbor site.

5.3.2.1 Sediment Treatment

Several sediment treatment technologies (e.g., incineration) have been thoroughly demonstrated as full-scale systems. Incineration is the most widely practiced and permitted method of destroying organic hazardous wastes. Incineration has been used during a removal action at several hazardous waste sites nationwide. A portable rotary kiln was used during a removal action at the Nyanza Site in Ashland, Massachusetts; the Naval Construction Battalion Center in Gulfport, Mississippi; and the Times Beach Dioxin Site in Times Beach, Missouri. Other sites that have used incineration include the Arco Swanson River oilfields in the Kenai Wildlife Refuge, Kenai Peninsula, Alaska; the Tillie Lewis Food Cannery Site in Stockton, California; the Cornhusker Army Ammunition Plant in Grand Island, Nebraska; and the Louisiana Army Ammunition Plant in Shreveport, Louisiana.

Incineration has been demonstrated for PCB wastes ranging from dilute aqueous streams (i.e., less than 1 ppm PCB) to pure PCB oil wastestreams. Incinerators can handle materials ranging from zero to 100 percent moisture content, zero to 100 percent ash content, zero to 60 percent chlorine content, and materials with heating values ranging from zero to 25,000 Btu/lb. Incineration appears to be a feasible treatment technology for New Bedford Harbor sediment.

Specific operating parameters can be optimized during the design phase. For the purposes of the estuary and lower harbor/bay FS, worst-case conditions were assumed (i.e., low Btu/lb heating value, high chlorine, and high moisture).

Three types of incineration systems were considered applicable for treating PCBs in New Bedford Harbor sediment and were therefore retained for remedial alternative development: infrared, rotary kiln, and fluidized bed (E.C. Jordan Co./Ebasco, 1987c). All three systems achieve similar results, but differ in materials handling and hardware design. The selection of a specific incineration system for New Bedford Harbor would depend largely on the ability of the equipment to meet design specifications developed for New Bedford Harbor and the availability of equipment at the time of implementation. Each incineration system is described in detail in the Jordan/Ebasco report (E.C. Jordan Co./Ebasco, 1987c).

Initially, the available literature information and bench- and pilot-scale performance data for many of the other sediment treatment technologies appeared promising for the New Bedford Harbor site. However, the site- and waste-specific conditions under which the tests were run were often dramatically different from conditions found at the site. In addition, much of this information was generated from earlier stages of technology development and did not necessarily reflect advances in process development that had occurred at the time these technologies were being evaluated for the New Bedford Harbor site. Therefore, the bench-scale treatment program was conducted to ensure that any remedial alternatives incorporating treatment technologies reflected state-of-the-art information and data specific to the New Bedford Harbor site.

Six bench-scale tests and one pilot-scale treatment test were conducted to provide performance data specifically for New Bedford Harbor sediment. No treatment tests were conducted for the three incineration options. The specific sediment treatment technologies tested are listed in Table 5-4. Details of the treatment test protocols are in the Jordan/Ebasco report (E.C. Jordan Co./Ebasco, 1987e).

Results of the sediment treatment tests conducted for the New Bedford Harbor project were used to determine the following:

- o effectiveness of the treatment technologies on treating PCB- and metals-contaminated sediment and water from New Bedford Harbor

- o potential material-handling problems and process rate-limiting features that might develop during scale-up of the treatment technology

- o refined cost estimates for treating New Bedford Harbor sediment

Results of the sediment treatment test program are summarized in Table 5-5. Brief descriptions of each sediment treatment technology and general comments regarding test results are discussed in the following paragraphs.

Solvent Extraction - BEST Process. Resource Conservation Company (RCC) conducted a bench-scale study of its BEST solvent extraction process on a sample of New Bedford Harbor sediment (RCC, 1988a). The BEST process employs the inverse miscibility property of the solvent triethylamine (TEA) to separate PCB-contaminated sediment into PCB/oil, water, and solids fractions. Sediment containing PCBs is mixed with TEA at a temperature of approximately 40 degrees Fahrenheit. At this temperature, the TEA freely mixes with the water and the PCB/oil fraction of the sediment matrix. After a suitable reaction period, the extracted solids are removed from the reaction mixture by centrifugation. The remaining liquid containing water, TEA, and PCB/oil is then heated to greater than 150 degrees Fahrenheit. At this elevated temperature, the water separates from the TEA/PCB/oil fraction. The TEA solvent is recovered by steam-stripping from the PCB/oil fraction and reused. The PCB/oil fraction is disposed of, usually by incineration, at a permitted, off-site facility.

Results of the BEST study are summarized in Table 5-5. PCB removal efficiencies of 99+ percent were achieved after three extraction stages for both high- and low-level sediment samples tested (initial PCB concentrations of 5,800 and 420 ppm, respectively). The PCB concentration in treated residue of the low-level sediment was 11 ppm; however, in the treated residue of the high-level sediment, it was 130 ppm. As a result of this finding, RCC conducted an additional bench-scale test on New Bedford Harbor sediment to further optimize process parameters. In the second test, a sediment sample containing 11,000 ppm of

TABLE 5-4
BENCH- AND PILOT-SCALE TESTS OF SEDIMENT TREATMENT TECHNOLOGIES

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

TECHNOLOGY	SCALE	VENDOR	CONTACT
Solidification/Stabilization	Bench	Test conducted by U.S. Army Corps of Engineers Waterways Experiment Station Vicksburg, Mississippi	Tommy Myers (601)-634-3939
Solvent Extraction			
BEST Process	Bench	Resources Conservation Co. 3006 Northup Way Bellevue, Washington	Lanny Weimer (301)-465-2887
Liquified Gas Extraction	Pilot	CF Systems Corporation 140 Second Avenue Waltham, Massachusetts	Tom Cody (617)-890-1200
Alkali Metal Dechlorination			
KPEG Process	Bench	Galson Research Corporation 6601 Kirkville Road East Syracuse, New York	Edwina Millisic (315)-463-5160
Vitrification (Modified In-situ)	Bench	Battelle Pacific Northwest Laboratories Richland, Washington	Craig Timmerman (509)-376-2252
Advanced Biological Treatment (Aerobic)	Bench	Radian Corporation 5103 W. Beloit Road Milwaukee, Wisconsin	Chuck Applegate (414)-643-2768
Sediment Dewatering			
Plate & Frame Filter Press	Bench	OH Materials Corp. 1090 Cinclare Drive Port Allen, Louisianna	Chuck Bearden (504)-389-9596

TABLE 5-5
RESULTS OF BENCH- AND PILOT-SCALE TESTS OF TREATMENT TECHNOLOGIES
CONDUCTED FOR NEW BEDFORD HARBOR

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

TECHNOLOGY	RESULTS OF TREATMENT TEST	ADVANTAGES	DISADVANTAGES	RETAINED
Solvent Extraction (B.E.S.T. Process)	o 99.1% reduction in PCBs in low level (780 ppm) sediment after three extraction stages o 99.4% reduction in PCBs in high level (4,300 ppm) sediment after three extraction stages o 94% reagent recovery o 90% solids recovery o Apparent immobilization of metals	o High PCB removal o Not limited by moisture content o Energy efficient o Proven in field test o Commercial units available	o TEA solvent is flammable o Secondary treatment for metals may be required	Yes
Alkali Metal Dechlorination (KPEG process)	o 99.8% removal of PCBs in low level (440 ppm) sediment after 9 hours o 99.8% removal of PCBs in high level (7,300 ppm) sediment after 12 hours o 75% reagent recovery (min) o 43% solids recovery (dry wt)	o High PCB removal o Biphenyl ether end product not acutely toxic, and does not bioaccumulate	o Low reagent/sediment recovery suggests material handling problems need to be overcome o Secondary treatment necessary for metals o Moisture inhibits dechlorination reaction o No commercial process available at present time	No
Solidification/ Stabilization	o Chemical stabilization properties of the three technologies tested were similar o Hardened material exceeded 50 psi EPA-OSWER standard o PCB leachability reduced by one to two orders of magnitude (depending on formulation)	o Effective stabilization of PCBs o Effective stabilization of cadmium and zinc o Numerous commercial processes available	o Apparent mobilization of certain heavy metals o No information or data on long-term structural integrity of solidified material	Yes

TABLE 5-5
(continued)
RESULTS OF BENCH- AND PILOT-SCALE TESTS OF TREATMENT TECHNOLOGIES
CONDUCTED FOR NEW BEDFORD HARBOR

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

TECHNOLOGY	RESULTS OF TREATMENT TEST	ADVANTAGES	DISADVANTAGES	RETAINED
Solidification/ Stabilization (continued)	o Cadmium and zinc leachability significantly reduced; eliminated in one process o Copper and nickel apparently mobilized			
Vitrification	o 99.94% destruction of PCBs o 99.9985% DRE (soil-to-offgas) o Metal concentrations in TCLP extract below regulatory limits	o Effective destruction of PCBs and encapsulation of metals	o High energy requirements o No commercial units available at this time	No
Liquified gas extraction (propane/ butane)	o TEST 2: Sediments containing 350 ppm PCBs were reduced to 40 ppm after 10 passes o TEST 3: Sediments containing 280 ppm PCBs were reduced to 82 ppm after three passes o TEST 4: Sediments containing 2,575 ppm PCBs were reduced to 200 ppm after six passes	o High PCB removal	o Further development needed to address problems with materials and system operating parameters experienced during pilot test o No commercial units available at this time	No
Advanced Biological Methods (aerobic)	o Limited degradation of lower chlorinated congeners (di- and trichlorobiphenyls)) o No degradation of higher chlorinated PCB isomer groups	o Insufficient data to assess advantages of this relative to other treatment processes	o Incomplete destruction of PCBs o Insufficient data to determine process rates and process design parameters	No

TABLE 5-5
(continued)
RESULTS OF BENCH- AND PILOT-SCALE TESTS OF TREATMENT TECHNOLOGIES
CONDUCTED FOR NEW BEDFORD HARBOR

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

TECHNOLOGY	RESULTS OF TREATMENT TEST	ADVANTAGES	DISADVANTAGES	RETAINED
Plate and Frame Filter Press	o 38% solids sample dewatered to 62% solids cake	o Effective method of sediment dewatering o Commercial units readily available	o None identified	Yes

NOTES:

KPEG = potassium hydroxide/polyethylene glycol
PCBs = polychlorinated biphenyls
ppm = parts per million
EPA = U.S. Environmental Protection Agency
OSWER = Office of Solid Waste and Emergency Response (EPA)
TEA = triethylamine
DRE = destruction and removal efficiency
TCLP = Toxicity Characteristic Leaching Procedure

PCBs was reduced to 16 ppm after six extraction stages (RCC, 1988b).

Similar PCB extraction efficiencies using the BEST process were obtained in other tests. A bench-scale test of PCB-contaminated soil was conducted by RCC for a northern New England utility. Three types of PCB-contaminated soil were tested: clay-silt, fill, and sandy loam. Initial PCB concentrations in these samples were 4,400, 1,010, and 21,700 ppm, respectively. Analysis of the treated soil showed residual PCB concentrations of 2.6, 5.9, and 19 ppm, respectively, after three extraction stages (RCC, 1989).

An Extraction Procedure (EP) Toxicity test was conducted by RCC on the treated New Bedford Harbor sediment. Results indicated that leachate concentrations of heavy metals were well below the allowable maximum concentrations. This apparent immobilization of the metals is presumed due to the alkaline nature (i.e., pH greater than 9) of the treated residue. The implication of this finding is that secondary treatment (e.g., solidification) of the solvent-extracted sediment may not be necessary to immobilize the heavy metals. However, the EP Toxicity test should be repeated after the treated residue has been normalized to the conditions expected in the disposal environment. Further bench- and pilot-scale tests to verify this phenomenon are warranted if the BEST process is chosen for the New Bedford Harbor site.

The hazardous nature of TEA and its reported toxicity to fish have raised questions about public and worker health and safety, and environmental impacts of the BEST process. TEA is a standard industrial solvent with a flash point of 25 degrees Fahrenheit; therefore, it is flammable. TEA is also mildly volatile, with a vapor pressure of 53.5 millimeters of mercury at 68 degrees Fahrenheit.

TEA is listed as a hazardous substance under CERCLA only on the basis of its flammability. TEA is not regulated by RCRA (i.e., the RCRA Solvents List) or by TSCA (i.e., the TSCA Reporting Chemical List). Residual TEA left in soils has been shown to rapidly degrade in the environment. Aerobactor, a common soil bacteria, was shown to degrade TEA completely within 11 hours (EPA, 1983a).

The human health exposure effects for TEA have been extensively investigated. TEA has been characterized as mildly toxic by ingestion and skin contact, and mildly toxic by inhalation (Sax and Lewis, 1984). No carcinogenic properties have ever been found. TEA can be detected by smell at extremely low concentrations below 1 ppm. The characteristic that allows TEA to be detected by smell at very low concentrations is similar to most amines and ammonia. The OSHA permissible exposure level

(PEL) for an 8-hour work day on a time-weighted averaged (TWA) basis is 25 ppm, two orders of magnitude higher than the level at which TEA is detected by smell.

Toxicity studies have been conducted with TEA on laboratory rats by the National Institute for Occupational Safety and Health in Cincinnati, Ohio. No adverse effects were observed in rats exposed to 250 ppm of TEA vapor for 6 hours per day, five days per week, for six months. When TEA levels were raised to 1,000 ppm for 6 hours per day for 10 days, the rats showed damage to mucous membranes in nasal passages, trachea, and lungs. Other laboratory experiments testing the effects of TEA inhalation have shown an LCLo (lowest published lethal concentration) of 1,000 ppm for 4 hours for both guinea pigs and rats (Sax and Lewis, 1984).

Comparison of the threshold for smell, the PEL/TWA, and the laboratory experimental data indicate that fugitive TEA emissions would become noticeable to workers long before permissible exposure to health-threatening levels had been reached.

Laboratory experiments testing the effects of ingestion of TEA have shown LD50 (lethal dose 50 percent kill) values of 460 mg/kg (body weight) and 546 mg/kg for the rat and mouse, respectively (Sax and Lewis, 1984). These data indicate that a significant quantity of pure TEA would have to be ingested by an average 70-kg adult to be life-threatening.

RCC uses numerous precautions in its system to minimize hazards. All process equipment is designed to operate as a closed system so that no TEA is released into the air as air emissions or becomes available for direct contact with equipment operators. Explosion-proof equipment, properly installed wiring, and nonsparking tools are used. In addition, operators and maintenance personnel receive extensive training on the safety-related aspects of handling TEA and the potential health impacts of TEA exposure. Minimum protective equipment, consisting of boots, overalls, hard hat, and goggles, is worn by all personnel when working on the site within the BEST unit perimeter. Personnel actually working on the unit could be required to wear breathing protection as an additional safeguard against possible fugitive releases of TEA.

The BEST extraction process has been successfully demonstrated on a pilot-scale at a Savannah, Georgia, Superfund site. This demonstration used the RCC prototype 100-ton-per-day multistage treatment unit. RCC bench-test protocols, which were used to evaluate the treatability of New Bedford Harbor sediment, have been developed and optimized to simulate the process dynamics of its prototype unit. Therefore, it is expected that these bench-scale results can be achieved in a full-scale unit deployed for the New Bedford Harbor site.

Currently, RCC is pilot-testing a different process hardware system using Littleford rotary washer/dryer units. The washer/dryer is a horizontal cylindrical vessel that has a rotating shaft with mixing paddles attached. These units are readily available and are used extensively in the chemical-processing industry. One major advantage of this processing system is that sediment-solvent mixing is more uniform, thereby increasing the extraction efficiency per stage (or wash cycle). In addition, the sediment is not moved from one reaction stage to the next (as it was in the prototype system), which simplifies material handling.

Within the last few months, RCC has completed a pilot-scale demonstration of its new process hardware at a CERCLA site in Greenville, Ohio. A Littleford Model FM-30 washer/dryer vessel was used on the pilot plant unit. This model washer/dryer is identical to the units the manufacturer uses in pilot tests for scale-up to commercial-scale units. Therefore, the extraction and drying performance of the unit is comparable in the larger-scale units.

Approximately 1,000 pounds of site soil with a PCB contamination level of 130 ppm was processed in 18 distinct batches. A treatment standard of less than 10 ppm residual PCBs in the treated soil was required. Process conditions were optimized throughout the test so that the residual levels of PCBs consistently decreased. The final five batches contained residual PCBs in the 2-ppm range (Weimer, 1990).

The average solvent residual in the treated soils was approximately 130 ppm, less than the 150-ppm goal for this site. PCBs were not detected in the untreated process wastewater at a detection limit of 20 ppb. Residual solvent concentrations in the untreated process wastewater were approximately 7.2 ppm (Weimer, 1990).

Application of this process system at the site would require additional pilot-scale tests to develop operating and design data for configuring a BEST treatment unit for treating New Bedford Harbor sediment.

Costs for treating New Bedford Harbor sediment using the BEST process were estimated by RCC to be $70 and $143 per ton, based on 450,000 and 46,000 cy of sediment treated, respectively. These costs do not include the disposal of the extracted PCB/oil fraction. Estimates obtained by RCC for the incineration of PCB-containing oil at an approved off-site facility ranged from $0.11 to $0.33 per pound (including transportation) (RCC, 1988a).

The BEST process was retained as a viable solvent extraction technology for treating New Bedford Harbor sediment. Results of the solvent extraction bench-scale test indicate that efficient removal of PCBs is possible. This technology is also commercially available at the present time.

Solvent Extraction - Liquified Gas Extraction. In July 1988, the EPA Superfund Innovative Technology Evaluation (SITE) program selected New Bedford Harbor as the demonstration site for a pilot-scale test of the CF System liquified gas extraction process (Science Applications International Corporation, 1988). The demonstration took place at the New Bedford Harbor site during the fall of 1988. CF Systems uses a mixture of liquified propane and butane at 240 pounds per square inch (psi) and 69 degrees Fahrenheit. The combined properties of gas diffusivity and liquid solvency allow the liquified propane and butane to mix readily with PCB-contaminated sediment, extracting the PCBs. The solvent-PCB mixture is separated from the solid and water phase. The pressure of the solvent-PCB mixture is then reduced to vaporize the solvent, which allows its separation from the PCBs. The solvent is recovered and compressed back to liquid form for use.

Results of the pilot test are summarized in Table 5-5. Although PCB-removal efficiencies of 90 percent were achieved for sediments containing PCBs ranging from 350 to 2,575 ppm, multiple passes or recycles through the treatment unit (up to 10) were required to obtain these results. Recycling was necessary during the pilot-scale test to simulate the performance of a full-scale commercial system. The CF Systems full-scale designs do not include recycling, because additional extraction stages and longer processing times are involved (Science Applications International Corporation, 1989). However, the basis or design procedure for scaling up the pilot-scale batch test results obtained at the New Bedford Harbor site to a commercial-scale, continuously fed unit needs to be addressed.

A material balance of the system indicated that 93 percent of the total solids mass was recovered; however, but only 48 percent of the known mass of PCBs was accounted for in effluent streams (Science Applications International Corporation, 1989).

Several operational control and equipment- and material-handling problems were experienced during the pilot-scale demonstration, including the following (Science Applications International Corporation, 1989):

- o plating of PCBs on the internal surfaces of the extraction vessels and piping
- o foaming of propane

- carryover of solids in the extract samples

- intermittent retention and discharge of feed material solids

- fluctuations in solvent flow and solvent/feed rates

Projected costs for treating New Bedford Harbor sediment using the liquified gas extraction process range from $148 to $447 per ton, including material handling and pre- and post-treatment costs (Science Applications International Corporation, 1989).

Liquified gas extraction was not retained as a viable treatment technology at this time for treating New Bedford Harbor sediment. Problems with materials handling, system operating parameters, extraction efficiencies, and low throughput rates observed during the New Bedford Harbor pilot demonstration suggest further research and development is necessary before full-scale implementation.

<u>Alkali Metal Dechlorination</u>. Galson Research Corporation (Galson) conducted a bench-scale study of its potassium hydroxide/polyethylene glycol (KPEG) process (Galson, 1988). In this process, KPEG reagent is mixed with PCB-contaminated sediment to form a slurry. The mixture is heated, causing the dechlorination of PCBs.

Results of Galson's bench-scale test, summarized in Table 5-5, indicate that PCB-removal efficiencies of 99+ percent were achieved for both the high- and low-level sediment samples tested (initial PCB concentrations of 7,300 and 440 ppm, respectively). The PCB concentrations in the treated residue were 3.5 ppm for the high-level sediment sample after 12 hours of treatment, and 0.7 ppm for the low-level sediment sample after 9 hours (Galson, 1988). However, these results are based on a sediment-solids recovery averaging only 43 percent. Reagent recoveries ranged from a high of 110.8 percent for the polyethylene glycol reagent, to a low of 75.5 percent for the dimethylsulfoxide reagent. The relatively low reagent and sediment-solids recovery suggests that material-handling problems would have to be addressed in a full-scale operation.

The reaction products from the KPEG process have not been fully characterized. The available information indicates that PCBs are not totally dechlorinated to form a biphenyl ether, but are bound to a glycol to form what Galson refers to as a PCB salt. This PCB salt includes a biphenyl molecule that is still partially chlorinated. The ultimate fate of this PCB salt is unknown: it may stabilize, continue to dechlorinate, or degrade to a phenol. A more thorough analysis of the process chemistry is necessary and should include information on the fractions of the different types of reaction products formed; and the reaction conditions that affect the ratios of reaction products, information on the stability of these compounds in the environment, and information on the potential reversibility of this reaction through naturally occurring mechanisms.

Galson claims EPA toxicity tests have shown that the reaction products are not acutely toxic, do not bioaccumulate, and are not mutagenic. DeMarini and Simmons evaluated KPEG and KPEG-treated 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) for mutagenic effects in salmonella and for toxicity to the Hartley male guinea pig (DeMarini and Simmons, 1989). Their results indicated that neither the KPEG solution nor the KPEG-treated TCDD were mutagenic to the salmonella TA98 strain in the presence of rat liver S9. The KPEG-treated TCDD was toxic to TA98 and TA100 strains in the absence of S9. The study also showed that neither KPEG nor KPEG-treated TCDD caused lethality or any detectable pathological effects in the liver of the guinea pig.

Costs for treating New Bedford Harbor sediment using the KPEG process were estimated by Galson to be $98 and $120 per ton, based on 500,000 and 50,000 cy of sediment treated, respectively.

Subsequent to the bench-scale test conducted for New Bedford Harbor, Galson completed a pilot-scale demonstration of the KPEG process of PCB-contaminated soils at the Wide Beach Superfund site in Irving, New York (Galson, 1989). Initial PCB concentrations for two runs were 30 ppm (Run 1) and 260 ppm (Run 2). Final PCB concentrations were 0.7 ppm (Run 1) and 1.7 ppm (Run 2).

Contrary to the project title, the Wide Beach demonstration did not constitute a pilot-scale demonstration of the KPEG process because it did not simulate the reactor hardware and material handling methods that would actually be used for a full-scale operation. Pilot-scale demonstrations conducted by CF Systems at New Bedford Harbor and RCC at the Greenville, Ohio, site used scale-down systems of reactor hardware and materials handling processes that would actually be used in their full-scale systems. While Galson may have used hardware and procedures that conceptually represented the process, the actual hardware for a full-scale operation would be considerably different. Therefore, the basis for Galson's claim of a scale-up factor of 270:1 (i.e., pilot-scale to full-scale) is questionable. Galson acknowledged having problems with distillation, separation and recovery of solvents and reagents during the pilot test, but suggested that these problems would be resolved by the use of appropriate processing equipment that would be incorporated into the full-scale operation (Galson, 1989).

Results of the Wide Beach test also indicated that throughput rates and materials handling would appear to be a major problem. The two major factors in determining throughput rate are the moisture content and the concentation of PCBs in the feed. In the Wide Beach test, soils with a 20 percent moisture content and up to 260 ppm PCBs were processed using an estimated cycle time of 12 hours per batch. Based on this, it is reasonable to assume that New Bedford Harbor sediments having a 250 percent higher moisture content (assuming sediments are dewatered to 50 percent) and PCB concentrations up to two orders of magnitude higher will require cycle times considerably longer. While additional processing equipment can be used to offset the increase in cycle time, this may appreciably increase the capital cost of equipment.

Results of the Wide Beach test indicated an average soils recovery of 70.5 percent. This was considerably better than the solids recovery of 43 percent reported in the New Bedford Harbor bench-scale test. However, the loss of 30 percent solids indicates that materials handling associated with soils recovery has not been completely addressed. While the use of full-scale equipment may improve solvent recovery, the loss of solvent due to the reaction of the reagents with the soil encountered during the Wide Beach tests indicate that additional work may be warranted.

The projected costs for implementing the KPEG process at Wide Beach are significantly higher than the cost estimates given for New Bedford Harbor. Costs for sediment treatment at Wide Beach range from $273 to $301 per cy, depending on the clean-up level and the type of reactor used. These costs include disposal of PCB residuals but do not include sediment excavation, handling, or costs associated with the disposal of treated sediments. Site conditions at New Bedford Harbor could increase the costs of the KPEG process dramatically. Higher moisture content in the dewatered sediments would increase fuel costs (to evaporate the water); significantly increase cycle times resulting in less sediment processed per day and increasing operating and labor costs; and require larger equipment for distillation and separation of the condensed water/reagent mixture resulting in higher capital costs. Higher PCB concentrations would consume more reagent, significantly increase cycle time, and result in higher waste product production rates.

Alkali metal dechlorination was not retained as a viable treatment technology at this time for treating New Bedford Harbor sediment. A well-designed pilot- or full-scale demonstration of the actual reactor hardware and materials handling processes is needed to resolve questions of solids/solvent recoveries, throughput rates, and other system parameters. Galson has completed the equipment design for full-scale implementation at Wide Beach. Remedial activities at the site are expected to begin in the spring of 1990. Costs of the KPEG technology for New Bedford Harbor may be considerably higher than the costs presented for Wide Beach. Nonetheless, the current estimates approach the costs of incineration, which is a treatment process with a much lower degree of uncertainty.

Solidification. An S/S bench-scale study was conducted on New Bedford Harbor sediment by USACE as part of its EFS (Myers and Zappi, 1989). S/S is a treatment technique in which setting agents are mixed with a waste material to enhance the physical properties of the waste and to immobilize the contaminants within the waste. Typical setting agents include Portland cement, lime, fly ash, kiln dust, and slag, and combinations of these materials. Coadditives such as bentonite, soluble silicates, and sorbents are sometimes used with the setting agents to give special properties to the final products (Myers and Zappi, 1989). Solidification eliminates the free water in a semisolid matrix by hydration, causing physical stabilization of the end product in terms of improved engineering properties (e.g., bearing capacity and permeability). Chemical stabilization, in which the chemical form of the contaminants are altered to make them resistant to leaching, can also be accomplished by this treatment technique.

Composite sediment samples containing PCBs and metals were processed by USACE using three S/S technologies: (1) Portland cement, (2) Portland cement with Firmex proprietary additive, and (3) Silicate Technology Corporation (STC) proprietary additive. The Portland cement and Portland cement/Firmex additive were tested in three formulations, which differed with respect to the dosage of setting agent. The Portland cement/sediment formulations (wet-weight sediment basis) were 0.1:1.0, 0.2:1.0, and 0.3:1.0. The Portland cement/Firmex additive/sediment formulations were 0.2:0.1:1.0, 0.15:0.15:1.0, and 0.1:0.2:1.0. The STC process was tested using one STC sediment formulation of 0.3:1.0 (Myers and Zappi, 1989).

The treated sediment was subjected to unconfined compressive strength (UCS) testing to assess physical stabilization. Batch leaching tests using distilled-deionized water were conducted to assess chemical stabilization. A sequential batch leaching test was conducted to evaluate chemical stabilization of metals.

Results of the S/S study are summarized in Table 5-5. Results of the UCS tests showed that New Bedford Harbor sediment can be converted to a hardened mass. The range in 28-day UCS was 20 psi (0.1:1.0 Portland cement/sediment) to 481 psi (0.3:1.0 STC/sediment). In general, the strengths of solidified/stabilized New Bedford Harbor sediment using the formulations tested were above the range normally associated with hard clays (28 to 56 psi) and solidified industrial sludges (8 to 43 psi), but lower than the UCS for low-strength concrete

(2,000 psi) (Myers and Zappi, 1989). A minimum UCS of 50 psi was established by the EPA OSWER as an indicator of satisfactory solidification of hazardous liquids prior to landfilling. In all cases, except for the 0.1:1.0 Portland cement/sediment formulation, UCS measurements for S/S-treated New Bedford Harbor sediment exceeded 50 psi.

Batch leaching tests showed that the chemical stabilization properties of the three S/S processes were very similar. The leachability of PCBs was reduced by factors of 10 to 100. The leachability of cadmium and zinc was significantly reduced and, in one case (i.e., the Portland cement/Firmix process), eliminated. Copper and nickel exhibited increased mobility in all three S/S processes. The masses of copper and nickel leached from the solidified/stabilized sediment ranged from three to 27 times and from seven to 41 times the amount leached from untreated sediments, respectively. Of the three processes, the STC process mobilized copper and nickel to a lesser degree than the Portland cement and Portland cement/Firmex processes (Myers and Zappi, 1989). The mobilization of copper and nickel may be due to changes in the interphase transfer processes for these two metals; however, this has not been confirmed.

Although USACE tested different formulations of three S/S processes, no process optimization work was conducted to improve the chemical stability of the treated sediment with respect to immobilizing copper and nickel. Studies of S/S as a treatment technology for contaminated soils were conducted by EPA's Office of Research and Development (EPA, 19__). Synthetic soils containing contaminants most frequently found at Superfund sites were used for these tests. The inorganic contaminants included copper and nickel. Three generic S/S processes were tested: Portland cement, lime kiln dust, and a 50:50 mixture (by weight) of lime and fly ash. Toxicity Characteristic Leaching Procedure (TCLP) tests conducted on treated soil samples cured for 28 days showed that all three processes significantly reduced the leachability of copper. Nickel concentrations were at or below the detection limit for nickel. It is expected that, given the numerous commercial processes available, a formulation of solidifying agents is available to immobilize all heavy metals.

Costs for treating New Bedford Harbor sediment using S/S have been estimated at $100 per ton, based on quotations from various vendors (E.C. Jordan Co./Ebasco, 1987c). The actual cost for S/S will depend on the specific formulation selected, the implementation strategy, and the performance criteria.

S/S was retained as a viable sediment treatment technology for the New Bedford Harbor site. This technology could be applied as a primary treatment for PCB- and metals-contaminated sediment, or as a secondary treatment for metals following a technology such as incineration or solvent extraction, which would remove PCBs. Additonal bench- and/or pilot-scale tests would be required to determine an optimum S/S formulation that would effectively bind all metals.

Vitrification. Battelle conducted a bench-scale test of modified in situ vitrification of New Bedford Harbor sediment (Battelle, 1988). In the vitrification process, electric current is applied to molybdenum electrodes inserted in PCB-contaminated sediment. Temperature in excess of 3,600 degrees Fahrenheit destroys the organics (i.e., PCBs) and encapsulates the metals in a glass-like solid matrix.

Results of Battelle's vitrification bench-scale test are summarized in Table 5-5. Vitrification was found to be a highly effective method of destroying PCBs in New Bedford Harbor sediment. In addition, vitrification provided an effective method of immobilizing heavy metals by encapsulating them in the glass-like residue.

Costs for treating New Bedford Harbor sediment using vitrification were estimated by Battelle to be $310 and $290 per ton, based on 50,000 and 500,000 cy of sediment treated, respectively.

Although results of the bench-scale test were favorable, vitrification was not retained as a viable technology for treating New Bedford Harbor sediment. Modified in situ vitrification has not been demonstrated on a pilot- or full-scale for contaminated sediment or other high-moisture-content materials. Because vitrification could not be applied as an in situ treatment method at the New Bedford Harbor site, a processing system would have to be developed to vitrify batches of sediment. Currently, no hardware design has been completed. This fact, coupled with the high costs of treatment, makes vitrification less attractive than incineration.

Advanced Biological Treatment. Radian Corporation (Radian) conducted a bench-scale study of aerobic biological treatment of New Bedford Harbor sediment containing PCBs (Radian, 1989). Advanced biological treatment of sediment PCBs would be conducted in hardware systems similar to those used for biological treatment of wastewater in municipal and industrial wastewater treatment plants. These systems allow for enhancement and control of biological degradative mechanisms to a greater degree than natural or enhanced in situ degradation.

Cultures of microbes from sediment sources in the New Bedford Harbor estuary and from an anaerobic digester used to treat PCB-contaminated sewage sludge were acclimated to biphenyl as the only carbon source. The enriched cultures were then switched to PCB-contaminated sediment for test purposes.

Sediment from two specific sources was used to test PCB degradation. One source contained relatively high concentrations of PCBs (i.e., greater than 3,000 ppm); the second source contained lower concentrations (i.e., less than 1,000 ppm). Presumptive testing was performed to determine whether a net loss of PCBs occurred within the treatment system. Confirmation testing was performed to determine whether any net loss observed was due to microbial metabolism.

The presumptive tests consisted of operating laboratory-scale aerobic reactors in a daily draw and fill mode with an average hydraulic retention time of 14 days. The following results of the presumptive tests indicated that a reduction in PCB concentration was obtained in both the high and low PCB level sediment (Radian, 1989):

- After 42 days (three retention times), the overall reduction of PCBs ranged from 13 to 15 percent for the high-level sediment reactors, and 30 percent for the low-level sediment reactors.

- By isomer groups, the PCB reduction was greater for the less chlorinated species. For the high-level sediment, dichlorobiphenyls were reduced by 62 to 70 percent and trichlorobiphenyls by 32 to 40 percent. There was little removal of the higher chlorinated species.

- For the low-level sediment, some reduction in the levels of tetra- and penta-chlorobiphenyls was noted along with the removal of di- and tri-isomer groups.

- Dichlorobiphenyls were reduced by 79 to 82 percent, trichlorobiphenyls by 48 percent, tetra-chlorobiphenyls by 14 percent, and penta-chlorobiphenyls by 6 percent.

The goal of the confirmation tests was to determine the amount of PCBs removed by biological mechanisms by performing a PCB mass balance around the batch-operated reactors. However, the initial PCB level in the control digester was found to be twice that in the test reactors. Therefore, the amount of PCBs removed by biological mechanisms could not be differentiated from the amount of PCBs removed by physical/chemical processes (Radian, 1989). The pattern of PCB reduction in the confirmation tests was similar to that observed in the presumptive tests, as follows (Radian, 1989):

- The overall reduction of PCBs ranged from 27 to 70 percent for the high-level sediment reactors. Dichlorobiphenyls were reduced by 83 to 100 percent, and trichlorobiphenyls by 64 to 87 percent. For the higher chlorinated groups, the reduction ranged from zero to 7 percent in one reactor, to 51 to 100 percent in another reactor. The reason for the wide range in percent removal of these higher chlorinated groups is unknown.

- For the low-level sediment reactors, dichlorobiphenyls were reduced by 39 to 50 percent. Little or no removal of higher chlorinated groups was observed.

Radian noted that the formaldehyde added to the control reactors to inhibit biological growth affected the PCB analyses. Initial PCB concentrations in the control reactors were approximately double the initial PCB levels in the test reactors.

Results of the Radian tests indicate that a microbial culture capable of degrading PCBs in a brackish water environment such as the estuary in New Bedford Harbor can be developed. However, these results also indicate that only dichlorobiphenyls and trichlorobiphenyls were degraded to a significant extent under conditions simulating a full-scale aerobic system designed to treat large volumes of sediment.

The scope of work conducted by Radian did not include the generation of process kinetics data on PCB destruction or the optimization of process parameters. Radian suggested several potential mechanisms for enhancing the rate of PCB degradation: increasing the desorption rate, enhancing cometabolism, and manipulating reactor operation modes and population characteristics. However, Radian also noted that none of these methods would be practical for treating New Bedford Harbor sediment unless a mechanism were developed for degrading all PCB isomer groups.

Costs for treating New Bedford Harbor sediment using advanced biological methods are unavailable because of insufficient data on these processes.

Based on preliminary results, advanced aerobic biological treatment was not retained as a viable treatment technology for the New Bedford Harbor site. Considerable research and process development is needed to understand the mechanisms and kinetics that are prerequisites to designing and implementing a full-scale treatment system capable of degrading all PCB isomer groups. Lack of specific information makes it difficult to compare the effectiveness, implementation, and cost of biological treatment to other treatment technologies that are further developed.

<u>Sediment Dewatering</u>. Conventional technologies, such as the plate and frame press or the belt filter press, have been used successfully and dependably to dewater a wide range of industrial and mumicipal wastewater treatment facility sludges for years. Existing performance data indicate that these

technologies can achieve a solids cake with greater than 50 percent solids by weight (E.C. Jordan Co./Ebasco, 1987c). On this basis, a bench- and/or pilot-scale test of dewatering was not included in the original bench-scale treatment technology program conducted by Jordan/Ebasco. To evaluate a feasible remedial alternative, it was assumed that the Hot Spot Area sediment could be dewatered to a 50 percent solids cake for subsequent treatment.

During the course of the bench-scale program, Jordan/Ebasco was approached by O.H. Materials Corporation (OHM), a vendor of the recessed chamber plate and frame dewatering technology. OHM offered to conduct a single bench-scale test of its technology to determine the dewaterability of New Bedford Harbor sediment. The scope of services was limited to a simple physical analysis and one test conducted on a sample of New Bedford Harbor sediment. No chemical tests were conducted to determine the mass balance for PCBs. This work scope was not intended to be as rigorous as the test protocols set forth in the bench-scale treatment program work plan for the other treatment technologies tested (E.C. Jordan Co./Ebasco, 1987e).

Results of the dewatering test indicate that New Bedford Harbor sediment can be effectively dewatered to achieve a volume reduction of 50 percent and a cake solids content of up to 62 percent (see Table 5-5). The compression strength of the filter cake was measured at 1.25 tons per square foot. Dewatering New Bedford Harbor sediment would be a necessary first step prior to implementation of other treatment technologies (e.g., incineration).

The test performed by OHM also indicated a need for the addition of a small amount of lime (i.e., 0.05 lb/gal) to condition the sediment for dewatering. In addition to improving sediment dewatering characteristics, the lime will have several beneficial impacts. Lime added to sediment prior to dewatering followed by incineration will help neutralize hydrochloric acid produced by the incineration of chlorinated organics and, therefore, will help reduce the acid gas content of the primary combustion chamber effluent stream. Lime will also raise the pH of treated and untreated sediment, which will decrease the mobility of any residual metals. Lime may also reduce the amount of S/S reagent necessary for physical stabilization and enhance chemical stabilization processes.

The unit cost for dewatering New Bedford Harbor sediment was estimated by OHM to be $45 per cy ($31 per ton) based on a 38 percent solids influent compressed to a 62 percent solids cake and a volume of 600,000 cy in situ. Recent discussion with OHM personnel indicated that the unit cost to dewater a 25 percent solids influent to a 50 percent solids cake would be less because the final percent of cake solids is less. The filter press on which the cost estimates for the New Bedford Harbor site were based is capable of handling an influent stream from 1 percent solids on up. The controlling factor is the quantity and percent solids of the cake (Bearden, 1989). Based on these comments, the unit price of $45 per cy for dewatering is conservative.

5.3.2.2 Water Treatment

Treatment of liquid wastestreams generated as a result of remedial activities (e.g., dredging and sediment dewatering prior to treatment) at the New Bedford Harbor site will be necessary to remove PCB and metals contaminants before discharge. These contaminants will exist both in the dissolved phase and adsorbed to suspended solids.

Water treatment technologies such as chemical clarification and carbon adsorption have been proven at full-scale. Most of these technologies were developed for the treatment of municipal and industrial wastewater and, therefore, are considered applicable for treating the liquid wastestreams that would be generated at the New Bedford Harbor site. Water treatment technologies are described in detail in the Jordan/Ebasco report (E.C. Jordan Co./Ebasco, 1987c).

As part of its EFS, USACE conducted bench- and pilot-scale studies of procedures to improve the quality of effluent generated from the placement of dredged sediment in a CDF prior to discharge (Wade, 1988). These studies consisted of bench-scale settling tests, chemical clarification tests, and pilot-scale tests of wastewater treatment.

Settling tests were conducted in laboratory columns to develop data for predicting the settling behavior of New Bedford Harbor sediment. Sediment that remains in the water column as suspended solids constitutes a significant source of PCB and metals contamination absorbed to the sediment particles. In addition, the suspended solids can interfere with the water treatment process itself. The settling tests were conducted on three sediment types: (1) a composite sediment sample collected from the upper estuary, (2) sediment collected from the Hot Spot Area, and (3) potential capping sediment. Compression and flocculant settling tests were performed on all three sediment types; zone settling tests were performed on the estuary composite sample only. Details of test procedures are presented in the Wade report (Wade, 1988).

Chemical clarification jar tests were conducted to evaluate the effectiveness of various polymers for the removal of suspended solids in the CDF effluent that would not settle by gravity. The tests were conducted only on the upper estuary sediment sample using numerous cationic and anionic polymers in liquid, emulsion, and dry forms. Details of the polymers used and the test procedures are presented in the Wade report (Wade, 1988).

Based on results of the bench-scale settling and chemical clarification tests, USACE concluded the following (Wade, 1988):

- Settling tests for the upper estuary composite, Hot Spot Area, and potential capping sediment samples exhibited zone settling behavior typical of other saline sediment tested.

- Effluent TSS concentrations after 24 hours of settling were 140, 151, and 150 mg/L for the upper estuary composite, Hot Spot Area, and potential capping sediment, respectively.

- Chemical clarification using polymers is an effective treatment for removing suspended solids from CDF effluents. Best polymer performance was achieved using Magnifloc 1586C, which removed 82 percent of the suspended solids (42.5 mg/L TSS residual).

- Low-viscosity, highly cationic emulsion polymers were found to be the most effective, economical, and simplest to use to achieve reduction of suspended solids.

Only one polymer was tested during the pilot-scale study, Magnifloc 1596C, a more recent polymer mix produced by American Cyanamide and similar to Magnifloc 1586C. This polymer was added to the effluent in the secondary cell of the CDF. Results indicate that Magnifloc 1596C was not as effective during the pilot-scale study in removing suspended solids from CDF effluent when compared with results obtained during the bench-scale tests (Averett, 1989). The polymer did significantly reduce suspended solids levels in the CDF discharge when these levels were high (i.e., 880 mg/L) at the primary weir. The polymer was also toxic to the organisms used by EPA ERL in its toxicity testing. USACE recommends that inorganic coagulants (e.g., alum, ferric chloride, and lime), alone or in combination with polymers, should be evaluated for potential application in removing suspended solids from the New Bedford Harbor site wastewaters where effluent treatment is required and a treatment plant is used (Averett, 1989).

Pilot-scale tests of carbon adsorption and ultraviolet (UV)/peroxide treatment to remove dissolved PCBs and metals from the CDF effluent were conducted during the USACE pilot dredging and disposal study. Commercial carbon and UV/peroxide treatment units were installed and maintained by Peroxidation Systems of Tucson, Arizona. Effluent from the CDF was passed through a coarse sand filter to remove suspended solids prior to carbon or UV/peroxide treatment.

Bench-scale results indicate that carbon adsorption appears to be effective in reducing the dissolved concentrations of PCBs. However, data from the pilot study indicate that for influent concentrations near 1 ppb, carbon adsorption was ineffective in further reducing the PCB concentration. USACE noted that flow rate and contact time are critical parameters in maximizing the effectiveness of carbon adsorption. In addition, adsorption isotherms generated during laboratory tests indicate that adsorption of PCBs onto carbon will be a relatively inefficient process for treating the New Bedford Harbor site wastewater (Averett, 1989). The significance of this finding is that high doses of carbon may be required to bring effluent PCB concentrations down to the 1-ppb level. A possible explanation for the low efficiency may be that a substantial fraction of the PCBs remains adsorbed to colloidal particles, which pass through the sand filters and the carbon columns (Averett, 1988). Removal of this colloidal fraction (and associated PCBs) using microfilters may be necessary prior to final polishing by the carbon columns. Further tests are warranted before final design of the water treatment system.

The UV/peroxide system appeared to be effective in reducing dissolved PCB concentrations. An influent PCB concentration of approximately 10 ppb was reduced to 1.5 ppb following treatment (Averett, 1989). Additional sample analyses are currently being conducted to verify this result.

5.3.2.3 Summary

Three sediment treatment technologies were retained for the development of alternatives: incineration, solvent extraction, and solidification. Sediment dewatering using a plate and frame, or belt-filter press, appears to be effective for New Bedford Harbor sediment and will be retained as a supporting technology. Dewatering might also be used to reduce the volume of dredged sediment prior to final disposal in CDFs.

Chemical clarification was retained as a method of reducing suspended solids in wastewater streams generated during remedial action at the New Bedford Harbor site. Although the polymers that were effective in bench-scale studies were not as effective as full-scale, it is assumed that additional bench- and/or pilot-scale tests will identify inorganic coagulants that are effective in removing suspended solids and associated absorbed PCBs and metals.

Carbon adsorption and UV/peroxide appear to be effective methods for the removal of dissolved PCBs and metals in wastewater streams. Additional tests are needed to optimize the efficiency of both systems and to address potential adverse effects to biota from peroxide residuals.

5.3.3 Disposal

Five types of disposal technologies and/or siting options were retained from the screening process for further evaluation: in-harbor disposal technologies such as CAD cells, shoreline disposal technologies such as CDFs (i.e., within the influence of normal tidal fluctuations), ocean disposal, upland disposal sites (i.e., areas located within a 10-mile radius of the harbor area), and off-site disposal at permitted facilities.

In-harbor and shoreline disposal of contaminated sediment in CDFs and CADs was thoroughly evaluated by USACE as part of the EFS and the pilot dredging study. An overview of the laboratory tests conducted by the USACE Waterways Experiment Station (WES) is presented elsewhere (Averett and Francingues, 1988).

Disposal of PCB- and metals-contaminated sediment in upland disposal locations in the New Bedford Harbor area but away from the harbor, or in offshore (i.e., ocean) disposal locations, was eliminated from further consideration. Although these disposal options are technically feasible, lack of suitable sites, permitting conflicts, and the current regulatory environment which does not favor land disposal suggest that neither disposal option would be acceptable.

Off-site disposal of contaminated sediment at permitted landfill facilities was also eliminated from further consideration. Off-site disposal depends on the available capacity and permit status of the disposal facility receiving the material. Currently, the closest permitted facility is in upstate New York, and it has limited capacity for handling these PCB-contaminated sediments.

5.3.3.1 U.S. Army Corps of Engineers Laboratory Studies

Laboratory tests were conducted to provide data and information to assess the CDF/CAD volume required for the disposal of dredged sediment, and to determine the efficiency of the CDFs and CADs in containing the contaminants. These tests and the results are described in the following paragraphs.

Settling tests on composite sediment samples collected from the upper estuary were conducted to evaluate the consolidation characteristics of the dredged sediment. These tests were described in detail by Wade (Wade, 1988). This information is important in determining the storage capacity of the CDF and CAD facilities and the feasibility of depositing dredged sediment in a CAD cell. USACE used results of these tests to determine that the CDF volume required for dredged sediment storage would be approximately 1.4 times the in situ sediment volume. Maximum consolidation of the sediment would occur three to five years after placement (Averett and Francingues, 1988).

Capping effectiveness tests were conducted to determine the thickness of clean material that would have to be placed over contaminated sediment in CAD cells to isolate contaminants from the overlying water column. Results of these tests indicated that a cap thickness of 35 cm would provide an adequate physical seal against PCB breakthrough (Sturgis and Gunnison, 1988). An additional 20 cm would be required to prevent breaching of the cap by burrowing organisms (i.e., bioturbation). The required total cap thickness of 55 cm does not consider erosion and resuspension of cap material due to hydrodynamic forces. USACE estimated that a design thickness of approximately 90 cm (3 feet) should be sufficient to ensure that the minimum thickness of 55 cm (1.8 feet) is attained during placement because of limits on operational controls.

Elutriate and saltwater batch leaching tests were conducted on composite and Hot Spot Area sediment samples to predict the contaminant levels in the effluent discharged from the CDF and to predict contaminant release from dredging and CAD operations. Results indicated that the mean elutriate dissolved PCB concentration was 0.11 mg/L, which exceeds the marine water quality criteria (i.e., 0.01 mg/L). Heavy metals concentrations for copper and cadmium (i.e., 0.057 and 0.11 mg/L, respectively) also exceeded marine water quality criteria (i.e., 0.0029 and 0.043 mg/L for copper and cadmium, respectively) (Averett, 1988).

Tests were conducted to predict the quality of the surface runoff water from a CDF containing contaminated sediment. The tests were conducted on wet unoxidized sediment and air-dried oxidized sediment (Skogerbee et al., 1988). Results of these tests indicated that proper management of a CDF to remove particulates from surface runoff water would remove 90 to 99 percent of all contaminants (PCBs and metals) in the surface runoff. Concentrations of dissolved heavy metals (notably copper and zinc) were found to equal or exceed EPA criteria. This finding indicates that runoff treatment, capping, or immobilization of the contaminants may be required to eliminate soluble heavy metals in the surface runoff.

5.3.3.2 Conceptual Disposal Alternatives

Based on findings in the laboratory studies, USACE developed and evaluated conceptual disposal alternatives for the New Bedford Harbor site. The effectiveness, technical feasibility, and cost of various design options for the deposition of dredged contaminated sediment in CDFs and CAD cells located in the upper estuary were evaluated using EPA CERCLA criteria for evaluating remedial alternatives prescribed for Superfund sites (Averett and Palermo, 1988).

CDFs. Ten separate locations were identified for construction of CDFs (Figure 5-3). These locations are primarily intertidal, although a few would be built predominantly on dry land and two are designed as "island CDFs." Each facility would be constructed to a final elevation of +12 feet MLW if no liner system was incorporated, and +19 feet MLW to retain the same storage capacity if a RCRA Subtitle C-type liner system was installed. Table 5-6 presents the 10 CDFs considered with the associated capacity and locations within the study area.

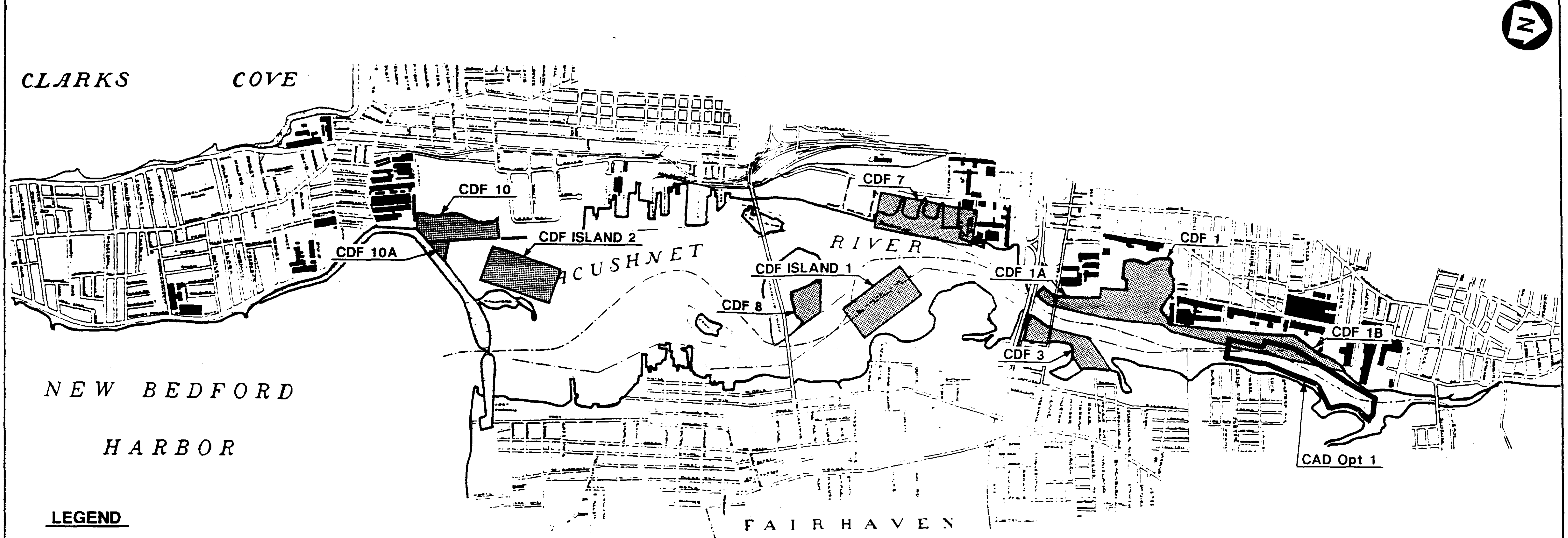
The conceptual construction for these CDFs is discussed in the following paragraphs. Because a decision has not yet been made whether these facilities would require liner systems, both types of facilities are discussed.

Liner systems for the CDFs may be necessary to ensure that contaminants do not migrate from the facility into the harbor. USACE conducted various tests to determine the effectiveness of the CDFs (see Subsection 5.3.3.1).

As part of the pilot study, USACE is evaluating leachate generation from and subsequent migration back into the estuary of PCB- and metals-contaminated sediment deposited in the pilot study CDF (see Subsection 5.3.3.3). Results of this study are not yet available. The obvious benefit of the liner is the collection of leachate containing PCBs and metals in soluble and suspended forms. The leachate would be treated prior to discharge back into the harbor system. However, lining CDFs would increase construction costs by more than 50 percent, as compared to construction costs for unlined CDFs. In addition, lined CDFs may be aesthetically unacceptable because of the additional height of embankments (i.e., 7 feet) necessary to compensate for the storage capacity taken up by the liner. Lined CDFs would also require additional O&M to collect and treat the leachate, as well as to monitor the liner system.

In summary, it should be emphasized that lining shoreline CDFs is only a conceptual design with numerous uncertainties associated with it, including costs, construction time, and the effectiveness of the liner.

The RCRA-type liner system would consist of a 1-foot layer of low-permeability material with a hydraulic conductivity of less than 1×10^{-7} centimeters per second (cm/sec). This material would be placed at or above +4 feet MLW to prevent saturation. Therefore, in-water portions of the CDF would be hydraulically filled with clean sand to the original elevation prior to liner placement. Naturally occurring clays that could meet these specifications are abundant in this area. A flexible membrane



LEGEND

POTENTIAL SHORELINE DISPOSAL SITES

CDF	VOLUME (cy)
CDF 1	270,000
CDF 1A	30,000
CDF 1B	90,000
CDF 3	134,000
CAD Opt 1	257,000
CDF 7	181,000
CDF 10/10A	267,000
ISLAND 1	354,000
CDF 4	20,000
CDF 8	42,000
ISLAND 2	246,000

SCALE IN FEET
0 2,000 4,000

FIGURE 5-3
DISPOSAL FACILITY SITING MAP
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

TABLE 5-6
POTENTIAL LOCATIONS AND CAPACITIES OF CONFINED DISPOSAL FACILITIES IN NEW BEDFORD HARBOR

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

CDF NO.	CAPACITY (Cubic Yards)	LOCATION
CDF 1	270,000	Estuary-Pilot Study Cove
CDF 1A	30,000	Estuary-Pilot Study Cove
CDF 1B	90,000	Estuary-Western Shoreline
CDF 3	134,000	Estuary-Eastern Shore Across from Pilot Study Cove
CDF 7	181,000	LHB-Western Shore Next to Conrail Railyard
CDF 10/10A	267,000	LHB-Western Shore at Hurricane Barrier
CDF Island 1	354,000	LHB-Open Water South of Marsh Island
CDF 4	20,000	EST-Between Coggeshall Street Bridge and I-195
CDF 8	42,000	LHB-Northeastern Corner of Pope Island
CDF Island 2	246,000	LHB-Open Water West of Palmer Island

liner would be placed above this material. Next, a 1-foot layer of sand would be placed with leachate collection pipes spaced 10 feet on center. Above this layer would be another flexible membrane liner and another 1-foot sand layer with leachate collection pipes. A geomembrane would be placed on top to prevent intermixing of the dredged sediment with the sand layer (Figure 5-4). Liner systems (described previously) would be installed on the bottom of each CDF. The top foot, including the membrane liner, would also be placed on the embankments (Averett and Palermo, 1988).

CDFs would be constructed in a manner that best uses the available area with minimal disruption of commerce and harbor traffic. Based on geotechnical investigations in the vicinity of the proposed CDFs, the construction sequence would occur as described in the following paragraphs.

For locations where the CDFs are sited within the 10-ppm TCL, that material would be removed first. Initially, the remaining storage capacity of the pilot study CDF could be used. The water dikes would be constructed in two stages, with geotextile placed along the dike alignment before placement of any fill. The first lift of granular fill material would have a 200-foot-wide footprint and 10:1 (vertical:horizontal) slope rising to approximately +5.0 feet MLW. Using wick drains to enhance consolidation and dewatering, a few months would be required before the dike has adequately settled. The second stage would be built at a 5:1 slope to a final elevation of +12 feet MLW. Stone would be laid along the outside of the water dike to an elevation of +8.0 feet MLW to prevent erosion resulting from tidal currents, river flows, and wave action. Geotechnical monitoring (e.g., piezometers and settling plates) would be required for the in-water dike section. The land dikes would be constructed with sand and gravel fill at a slope of 2.5:1. The outside face of this dike would be covered with topsoil and seeded.

A sheetpile dike would be constructed within the CDF to create a secondary cell for dewatered sediment supernatant. A walkway, weir, and outlet structure are included as part of the secondary cell. The CDFs would be capped with an impermeable material (after placement of a geomembrane) to prevent leachate development and public contact. The cap would be completed with a layer of topsoil and seeded after the sediment has sufficiently settled. Cross sections of typical in-water unlined and lined dikes, and land dikes, are shown in Figures 5-5 and 5-6, respectively.

A lined CDF would be constructed in a manner similar to the unlined CDF. The in-water dike for a lined CDF would be constructed in three stages. The first stage would consist of hydraulic fill placed over geotextile after removing

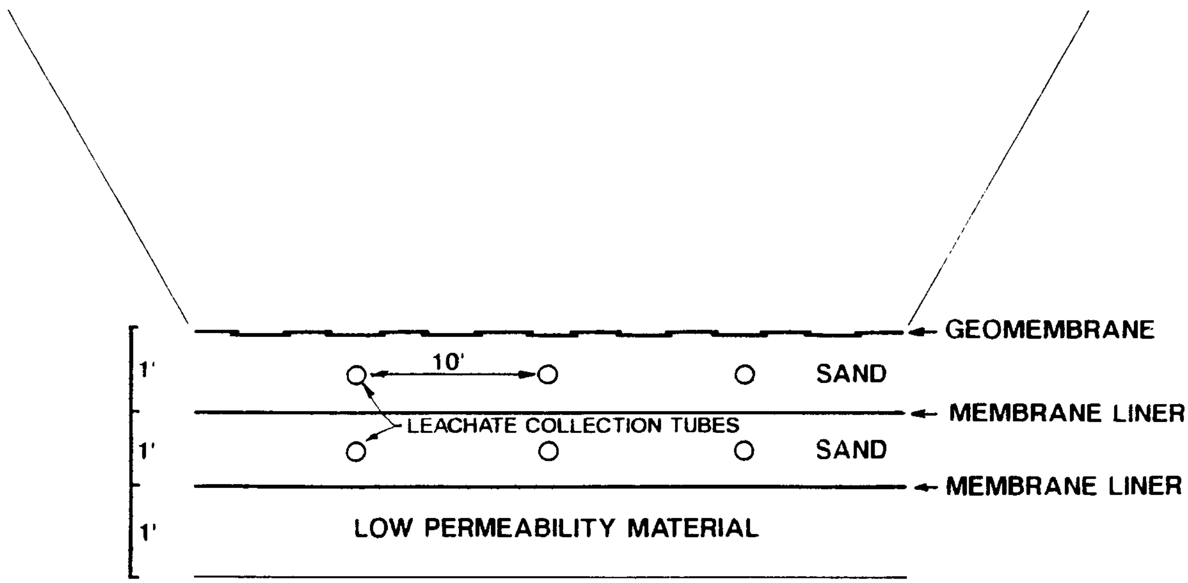


FIGURE 5-4
RCRA TYPE LINER SYSTEM FOR CONTAINED DISPOSAL FACILITIES
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR

NOT TO SCALE

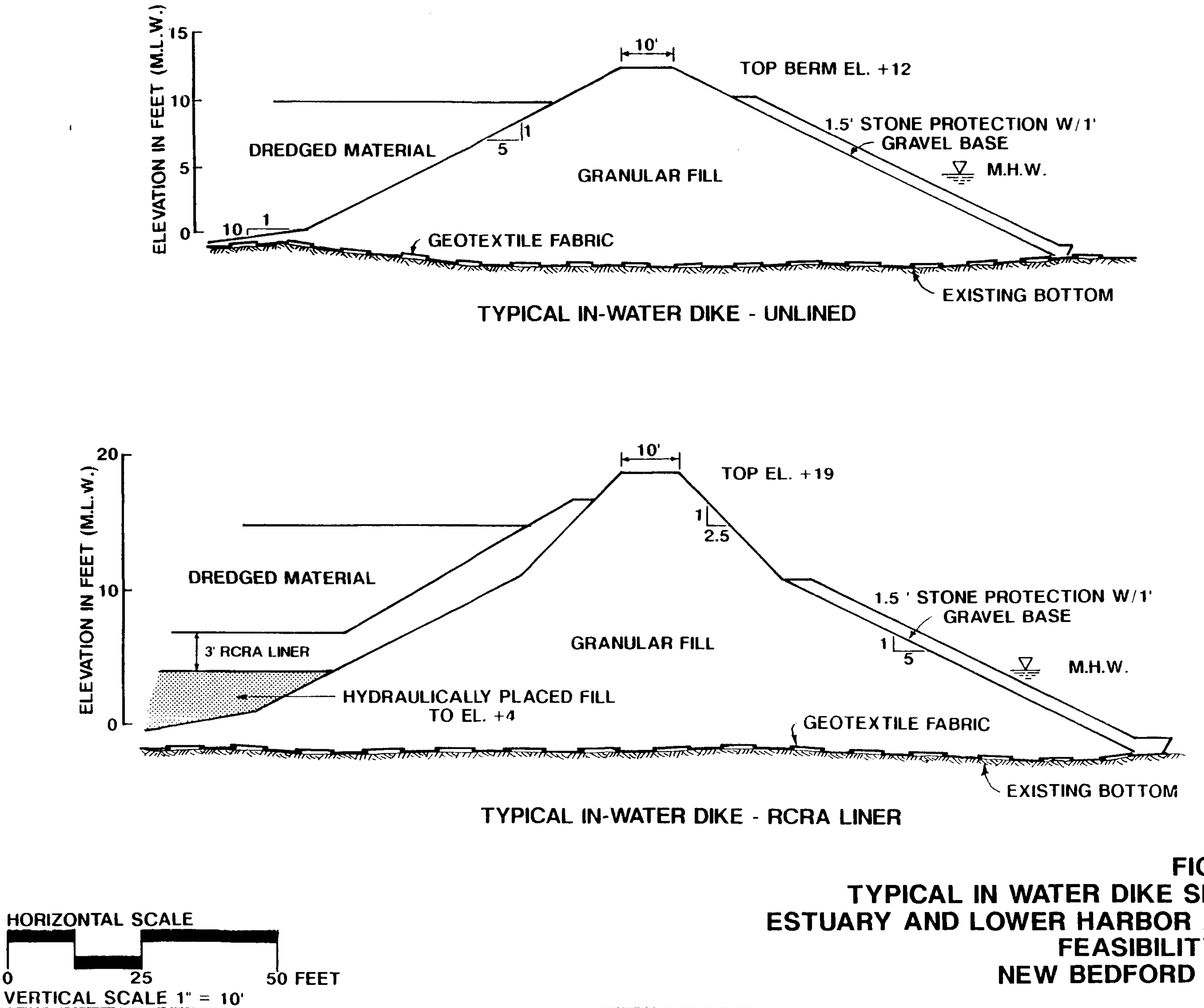


FIGURE 5-5
TYPICAL IN WATER DIKE SECTIONS
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

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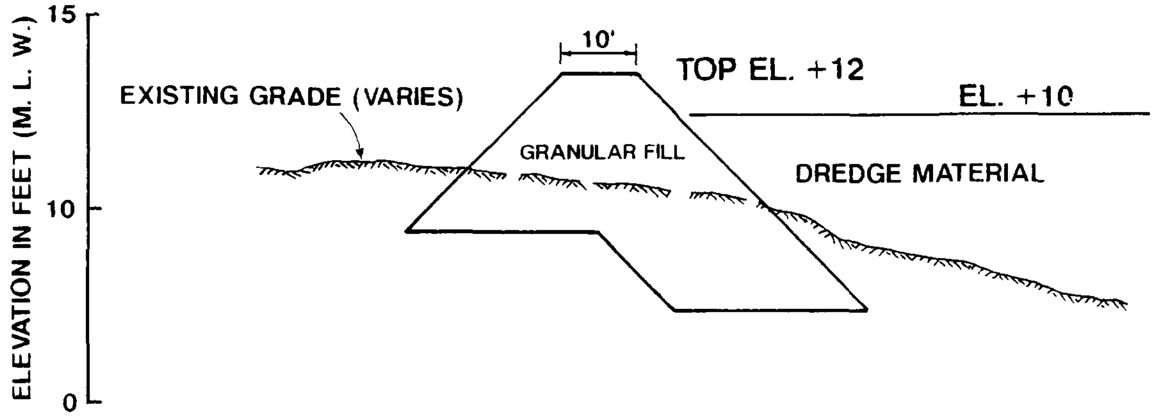
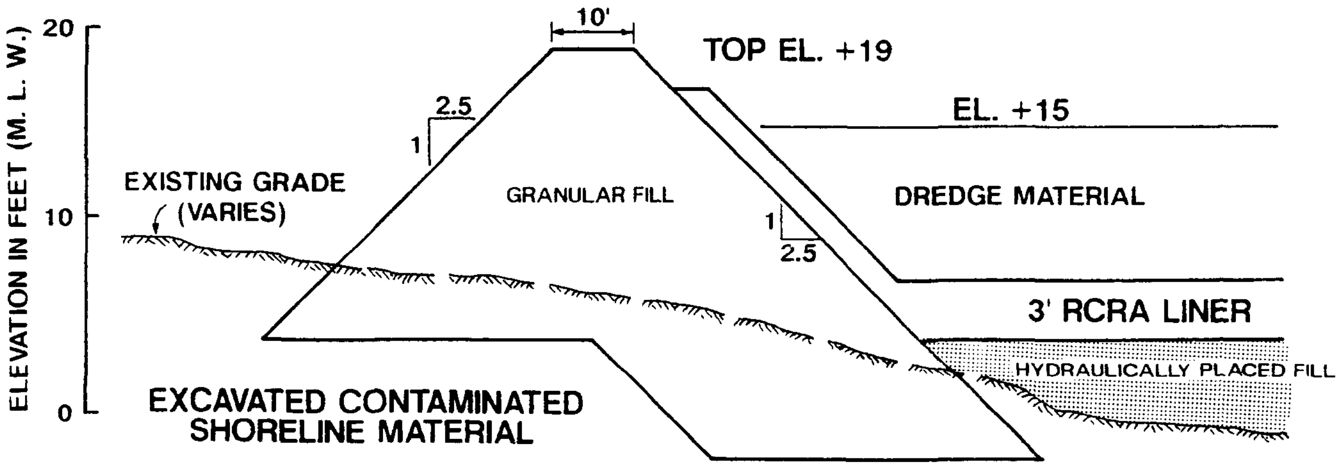


TYPICAL LAND DIKE UNLINED



TYPICAL LAND DIKE RCRA LINER

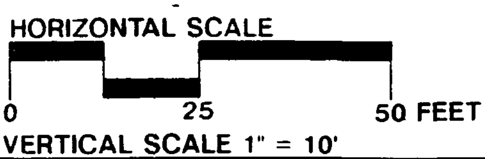


FIGURE 5-6
TYPICAL LAND DIKE SECTIONS
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-22

approximately 2 feet of contaminated sediments. A 320-foot-wide-base foundation is anticipated. The second lift would consist of granular fill at a 5:1 slope. The third lift would be constructed at a 2.5:1 slope, rising to a final elevation of +19.0 feet MLW. The extra height is necessary to replace the volume displaced by the liner system.

<u>CAD Cells</u>. The use of CAD cells involves "turning over" the surficial layer of contaminated material. This is accomplished by temporarily storing an initial portion of contaminated sediment. Clean sediment below this initial portion is then dredged to create the first cell and is also temporarily stored separately. Subsequent contaminated dredge material can then be pumped into the CAD cell. As that cell is filled, it is capped with the clean sediment dredged to create the second cell. This sequence continues until all dredge material is disposed of or all appropriate CAD locations have been used.

USACE determined that the only area acceptable for CAD cell placement is within the northern half of the upper estuary, excluding the narrow channel immediately south of the Wood Street Bridge. Excessive erosion rates and the potential for excessive loss of material during placement render the remaining area unacceptable (Averett and Palermo, 1988).

The typical CAD cell would be dredged to a 1:3 side slope, and a total depth of approximately -10 feet MLW. This would allow for dredge material filling to -3 feet MLW, and for an initial cap thickness of 4 feet. Final cap thickness after consolidation (estimated at 1 foot) would be 3 feet, resulting in a final elevation of zero feet MLW.

5.3.3.3 U.S. Army Corps of Engineers Pilot Study of Disposal Alternatives

Results of this study suggest that construction of shoreline CDFs is feasible. The procedures utilized in the pilot-scale study resulted in stable dikes with minimal impacts to water quality. The dikes would be placed on geotextile and fill placed in shallow lifts to allow adequate consolidations. The study does indicate that the size of the secondary cell can be scaled back to that of the design procedure. (The pilot-scale study secondary cell was oversized.) Effluent from the CDF had suspended solids levels (75 mg/L) similar to USACE's estimate of 70 mg/L. PCB and metals levels in the effluent were lower than estimates based on the modified elutriate test. These pilot study results indicate that the elutriate tests were conservative, especially when the CDF was not operating to capacity.

Disposal in the pilot study CAD cell resulted in suspended sediment and contaminant levels in the vicinity of the disposal operation. Transport of contaminants away from the CAD cells was limited, however, as no statistically significant increase in contaminant levels was detected at the Coggeshall Street Bridge. The diffuser worked most effectively when positioned close to the bottom of the cell. Deploying a silt curtain around the disposal activity may be advantageous.

The cap placed on the contaminated sediment intermixed with the sediments; USACE suggested that a deeper CAD cell would allow the diffuser to be positioned well above the contaminated sediment being discharged and still remain inside the cell. Geotextile could also be placed prior to capping to prevent intermixing.

A CDF and a CAD cell were constructed during the pilot-scale study to evaluate the effectiveness of these disposal options in containing contaminated sediment.

5.3.3.4 Summary

Disposal of contaminated sediment in in-harbor CAD cells and shoreline CDFs has been retained for the development of remedial alternatives. Studies conducted by USACE indicate that CDFs and CAD cells appear to be viable technologies for long-term storage of contaminated sediment. The long-term effectiveness and technical feasibility of CDFs and CADs will depend on the selection of appropriate siting locations with respect to geotechnical properties of underlying strata; operational procedures to miminize sediment resuspension during construction, filling, and capping of the CDFs and CAD cells; and proper management of CDFs and CAD cells in terms of long-term monitoring of structural integrity and potential leachate migration, and treatment of any effluents (Averett and Francingues, 1988).

5.3.4 Containment and In Situ Treatment

Two containment options, capping and hydraulic controls, and two in situ treatment options, biodegradation and solidification, were retained from the initial screening process for further evaluation. Details of the evaluation of these technologies are presented in the Jordan/Ebasco report (E.C. Jordan Co./Ebasco, 1987c). Results are briefly summarized in the following paragraphs.

Capping of waste piles, impoundments, and abandoned uncontrolled hazardous waste sites has been a widely accepted practice for controlling infiltration of precipitation and subsequent leaching of wastes, or as a final remedial action, usually in combination with other technologies. Subaqueous or level-bottom capping has been used extensively as a dredged material disposal alternative (Morton et al., 1984; Mansky, 1984; and Truit, 1987). Cap placement in subaqueous environments can be accomplished using either hydraulic or mechanical methods. The long-term structural integrity of the cap will depend on the cap material selected and the local hydrodynamic forces that cause scouring and resuspension of cap material. Capping was retained as a viable technology for the in situ containment of contaminated New Bedford Harbor sediment.

Hydraulic controls are barriers, constructed of granular material or sheetpile, that are placed in areas susceptible to hydraulic scour. These barriers reduce contaminant migration during technology implementation or from surface water flow. Hydraulic controls may be implemented in conjunction with other technologies, such as capping or dredging, deposition of sediment in CAD cells, or placement of subaqueous capping material. In these instances, hydraulic controls would serve to mitigate, if not eliminate, the migration of contaminated sediment resuspended during these operations. However, results of the USACE pilot dredging and disposal study indicate that the use of hydraulic controls would not be necessary during implementation of the technologies discussed previously, provided operational procedures designed to minimize sediment-contaminant resuspension are used. Therefore, hydraulic controls were only retained for consideration in controlling the Acushnet River flows in conjunction with the estuary capping alternative.

Enhanced in situ biodegradation relies on nutrient addition and control of physiochemical growth parameters for indigenous microbes and/or exogenous sources of microbes to degrade organic compounds. This technology should not be confused with natural in situ biodegradation (see Section 2.0), in which there is no manipulation of the environment to optimize degradation rates.

Enhanced in situ biodegradation as a remedial treatment process has been successfully applied in groundwater and soil contaminated with volatile and aromatic hydrocarbons, and for oily lagoon sludges. Numerous vendors offer commercial-scale bioremediation services employing natural biodegradation for these types of wastes.

Enhanced in situ biodegradation of PCBs as a remedial treatment process was evaluated during the initial screening and detailed evaluation of treatment technologies for the New Bedford Harbor site. This work was conducted during the spring and summer of 1987; the results were published in two reports (E.C. Jordan Co./Ebasco, 1987a and 1987b). Based on the available research and state-of-the-art process development at that time, it was concluded that (1) there was no conclusive evidence for the occurrence and mechanisms of natural biodegradation of PCBs; and (2) natural PCB biodegradation as a remedial treatment process had not been successfully demonstrated in any environment.

Since the publication of the treatment technology reports in 1987, numerous studies have provided scientific evidence that natural biodegradation of PCBs is occurring in the sediments of New Bedford Harbor and elsewhere. However, no attempt has been made to implement a field demonstration of biodegradation as a remedial process for PCBs in river or harbor sediments. General Electric, the principal PRP in the PCB contamination of the Hudson River, recently announced plans to demonstrate an in-river enhanced bioremediation system within the next two years (Clean Water Report, 1989). Currently, however, none of the engineering obstacles for implementing this system have been addressed in the conceptual design (Brown, 1989).

While enhanced in situ biodegradation of PCBs may offer the potential for an effective, low-cost treatment alternative, sufficient information and data are not currently available to address key process design issues, such as the rates of biodegradation; the mechanics of nutrient delivery systems and the logistics of monitoring and/or controlling physiochemical parameters affecting microbial growth and degradation capacities in unconfined sediments; and costs. Consequently, the effectiveness implementation and cost of enhanced in situ biodegradation as a remedial treatment process could not be assessed during the FS and no comparisons could be made to other treatment technologies (e.g., incineration and solvent extraction) being evaluated and for which this information was available. Therefore, enhanced in situ biodegradation was eliminated from further consideration.

In situ solidification is accomplished by injecting slurried cement into the sediment and mixing through rotary action using specially designed drilling equipment. To date, in situ solidification has been used only in Japan to solidify and strengthen sediment. The method has been effective for its intended purposes; however, it has not been used to treat hazardous wastes in sediment. In situ solidification of contaminated sediment at the New Bedford Harbor site does not appear to be practical for several reasons (E.C. Jordan Co./Ebasco, 1987d). The operation is usually conducted from a floating vessel with a draft of at least 10 feet. This would eliminate the use of this technology in the upper estuary where shallow (i.e., less than 6 feet) water conditions exist. The available performance data indicate that strengthening of the sediment increases with depth, which suggests that contaminants in the upper layers of sediment might not be completely immobilized. Quality control monitoring in a subaqueous environment would pose substantial problems and probably could not be ensured; this implies that immobilization of the contaminants might not be achieved. For these reasons, in situ solidification of contaminated sediment was eliminated from further consideration.

In summary, no in situ treatment technologies were retained for the New Bedford Harbor site. Only capping and capping with hydraulic controls were retained as viable containment technologies. Studies conducted by USACE indicate that capping is technically feasible with proper operational procedures designed to minimize sediment resuspension.

5.4 REMEDIAL TECHNOLOGIES APPLICABLE TO THE ESTUARY AND LOWER HARBOR/BAY

Figure 5-7 presents the technologies considered applicable for the estuary and lower harbor/bay. For remedial alternatives that require removal of the contaminated sediment, the cutterhead dredge will be used as the first remedial step. Options for alternatives using sediment treatment as a remedial component will consist of solvent extraction, solidification (both as primary and secondary treatment processes), and incineration. Process wastewater will be treated using settling, chemical-assisted clarification, carbon adsorption, and/or UV/peroxide. Disposal options for treated or untreated sediment include CDFs or CAD cells. Capping, with or without hydraulic controls, will be one nonremoval (i.e., containment) remedial alternative considered in the alternative development phase. The no-action alternative will also be developed for the estuary and lower harbor/bay.

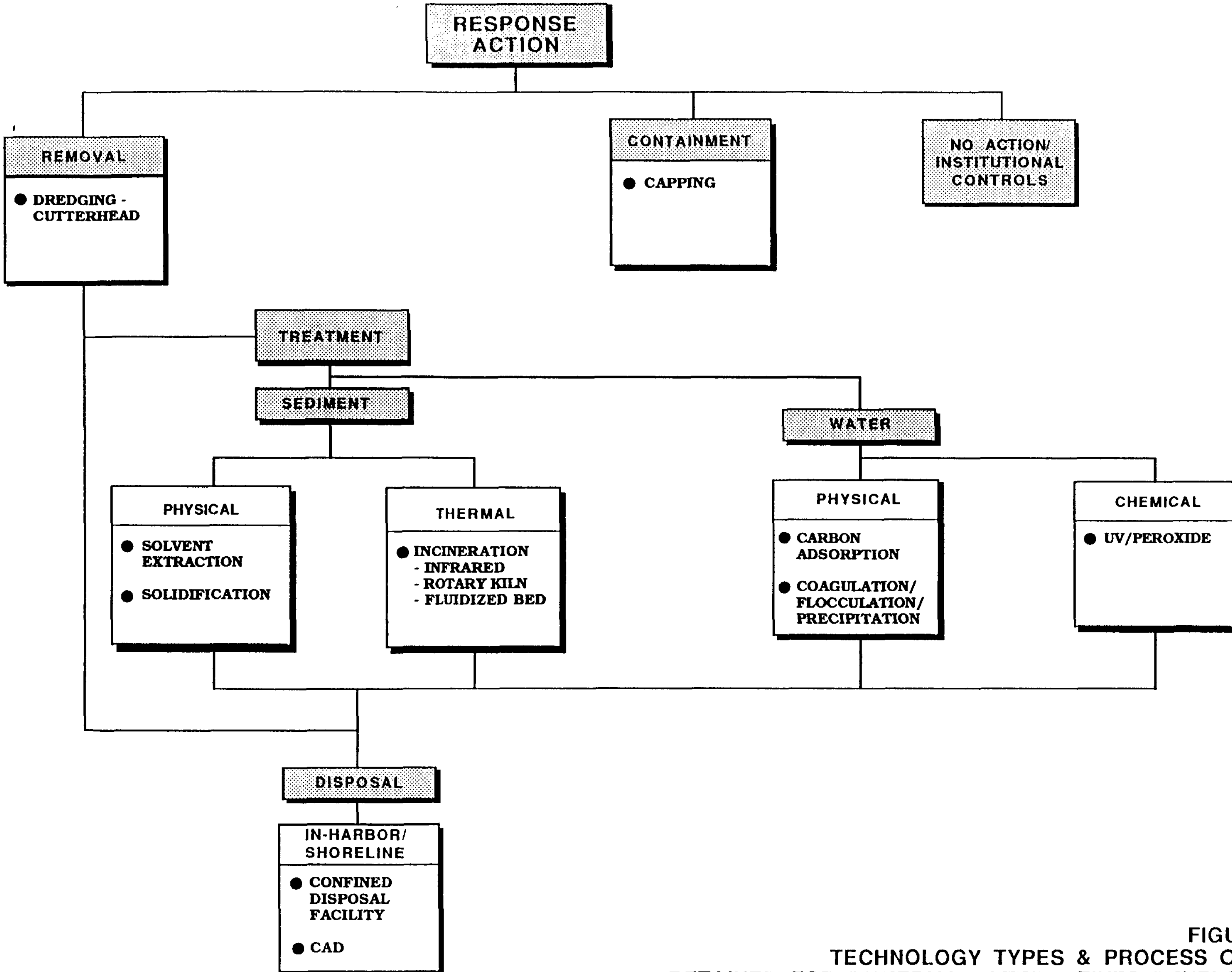


FIGURE 5-7
TECHNOLOGY TYPES & PROCESS OPTIONS
RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

6.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

In this section, the general response actions identified in Section 4.0 are combined with the technologies retained in Section 5.0 to form remedial alternatives for the estuary and lower harbor/bay. The alternatives meet the remedial action objectives developed for the site in Section 4.0. These alternatives are then screened on the basis of effectiveness, implementability, and cost.

6.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Applicable combinations of technologies selected in Section 5.0 were developed into remedial alternatives capable of meeting the remedial action objectives presented in Subsection 4.3. In accordance with SARA, the following types of alternatives must be considered to create a range of remedial actions for subsequent screening:

- the "no-action" alternative
- alternatives that permanently and significantly reduce the volume, toxicity, or mobility of the hazardous wastes
- alternatives that store, destroy, treat, or dispose of wastes at a compliant facility
- alternatives that do not require long-term management of the site
- alternatives that involve on-site containment
- alternatives that attain federal public health and environmental ARARs

Alternatives were developed for each of the two study areas: the estuary and the lower harbor/bay. For analysis purposes, the alternatives were subdivided into nonremoval and removal alternatives. Nonremoval alternatives leave the source material in place; these include no-action and containment. Removal alternatives require that the material be removed before subsequent treatment and/or disposal.

Flow diagrams were prepared to help visualize the development of alternatives, and to summarize results of the alternative development step. Subsections 6.1.1 and 6.1.2 present the alternatives developed for the estuary and for the lower harbor/bay, respectively.

6.1.1 DEVELOPMENT OF ALTERNATIVES FOR THE ACUSHNET RIVER ESTUARY

The Acushnet River Estuary, extending from the Coggeshall Street Bridge north to the Wood Street Bridge, is a tidal estuary covering approximately 187 acres. Sediment PCB concentrations in this area range from 10 to 4,000 ppm (excluding the Hot Spot Area). Sediment metals (i.e., cadmium, copper, lead, and zinc) have been measured in concentrations up to 5,000 ppm throughout the estuary, and up to 14,000 ppm in localized areas. However, there are some small isolated areas where no detectable quantities of PCBs and metals were identified. Because this is a tidal system, much of the area is shallow and becomes mudflats during low tide. In addition, the eastern shore contains approximately 50 acres of high saltmarsh.

To meet the proposed TCL of 10 ppm for PCBs, each alternative (except the no-action alternative) requires that a certain amount of sediment be remediated. For the nonremoval alternatives, approximately 164 acres of the estuary would need to be remediated. For the removal alternatives, this acreage translates to approximately 528,000 cy of estuary sediment that would require remediation (assuming a 2-foot depth of contamination).

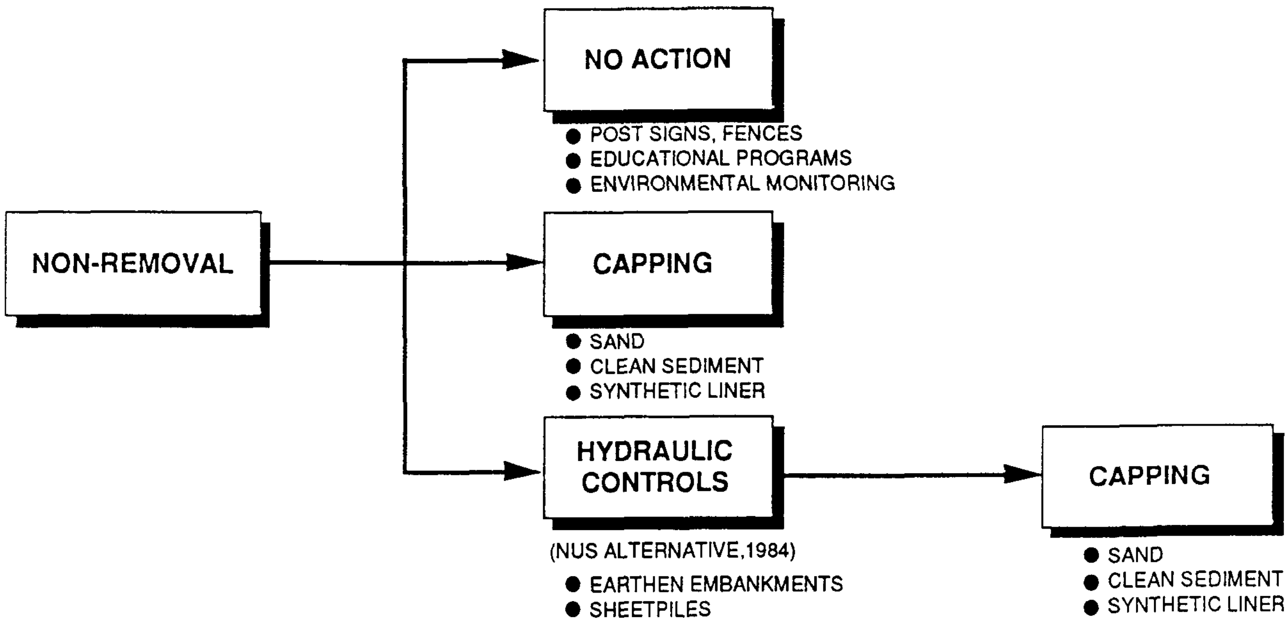
Three nonremoval and five removal alternatives were developed for the estuary. Figures 6-1 and 6-2 present a flow chart and brief description of these alternatives, which are identified by the "EST-" prefix. The no-action alternative, EST-NA-1, serves as a baseline for comparison with the other nonremoval and removal alteratives developed for the estuary. The capping alternatives, EST-CONT-1 and EST-CONT-2, constitute remedial alternatives involving on-site containment. Alternative EST-CONT-2 was originally developed as a remedial option in the NUS FS of the upper estuary (NUS, 1984a and 1984b). This alternative is re-examined in this FS in view of additional capping studies conducted by USACE (see Section 5.0).

The five removal alternatives developed for the estuary involve removal of the sediment followed by direct disposal, or a treatment option and subsequent disposal of the material elsewhere. Disposal options are shoreline or island CDFs and CAD cells. Sediment treatment options are solidification, solvent extraction, and incineration. The applicable supporting technologies (e.g., dewatering) and secondary treatment options are also included.

6.1.2 DEVELOPMENT OF REMEDIAL ALTERNATIVES FOR THE LOWER HARBOR/BAY

Alternatives similar to those for the Acushnet River Estuary were developed for the lower harbor/bay. The New Bedford lower

FIGURE 6-1
DEVELOPMENT OF NON-REMOVAL ALTERNATIVES
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR

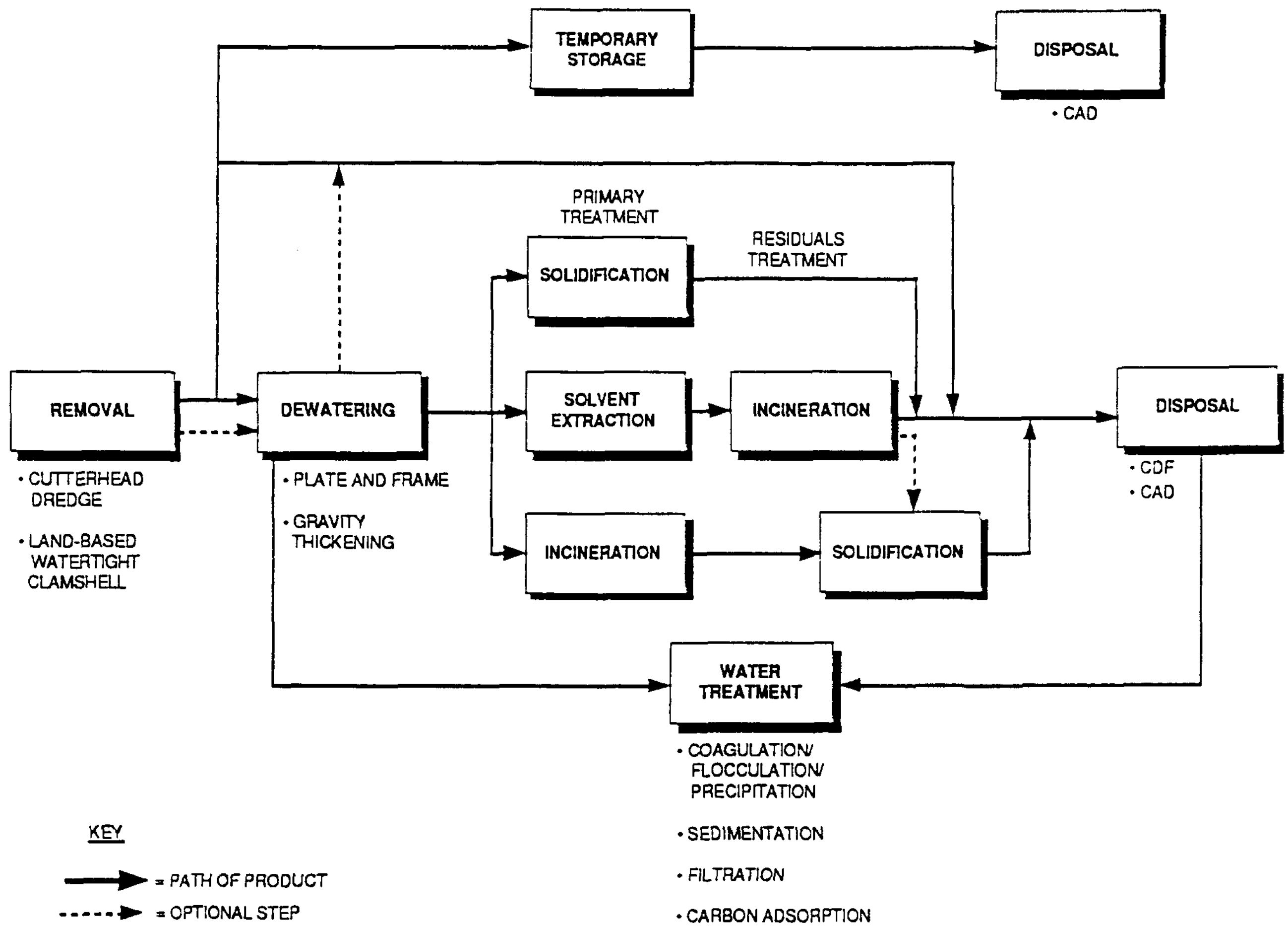


<u>EST-NA-1 AND LHB-NA-1:</u> <u>NO-ACTION ALTERNATIVE</u> - Maintain signs, fences, educational programs, and ban on fishing; continue environmental monitoring.

<u>EST-CONT-1 AND LHB-CONT-1:</u> <u>CAPPING ALTERNATIVE</u> - Cover contaminated sediments with clean sand or sediment. Armor erosional areas with rip-rap.

<u>EST-CONT-2:</u> <u>HYDRAULIC CONTROL /CAPPING ALTERNATIVE</u> - Construct a channel the length of the estuary using earthen embankments; cap sediment within and adjacent to the channel.

FIGURE 6-2
DEVELOPMENT OF REMOVAL ALTERNATIVES
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR



EST-DISP-1 AND LHB-DISP-1: ON-SITE DISPOSAL ALTERNATIVE - This alternative involves dredging contaminated areas with a cutterhead dredge, and disposing of the dredged slurry in on-site CDF and/or CAD facilities. Contaminated supernatant would be drawn off from the CDF disposal sites for treatment. A mechanical dewatering step may be necessary prior to on-site CDF disposal in order to maximize available disposal space.

EST-DISP-2: DREDGE/TEMPORARY STORAGE/DISPOSAL CAD ALTERNATIVE - Dredge area of sediment; store sediment temporarily; dredge clean sediment below contaminated sediment and store; dredge next area of contaminated sediment and dispose of in depression created in first section; cover with clean sediments from that next area; continue this sequence and use temporarily stored sediments to fill last depression.

EST-TREAT-1 AND LHB-TREAT-1: SOLIDIFICATION ALTERNATIVE - This alternative involves dredging contaminated sediments, transporting the dredged slurry to an onshore facility for dewatering, treating the water, treating the dewatered sediment by solidification, and disposal of the treated sediments in a lined or unlined on-site facility having a leachate collection and treatment system.

EST-TREAT-2 AND LHB-TREAT-2: SOLVENT EXTRACTION/RESIDUALS TREATMENT ALTERNATIVE - This alternative would involve dredging the contaminated sediments, transporting the dredged slurry to an onshore facility for dewatering, treating process water, treating the dewatered sediment using solvent extraction, incinerating the PCB/oil extract, solidifying the treated sediment, and disposing of the treated sediment in an on-site disposal facility.

EST-TREAT-3 AND LHB-TREAT-3: INCINERATION/RESIDUALS TREATMENT ALTERNATIVE - This alternative involves dredging the contaminated sediments, transporting the dredged slurry to an onshore facility for dewatering, treating the process water, incinerating the sediment, solidifying the residual, and disposing of the solidified product in an on-site disposal facility.

harbor/bay study area is large (i.e., approximately 1,045 acres) and complex in nature. Its complexity is due in part to the wide variation in bathymetry, and in part to the current and potential utilization of the lower harbor and its waterfront. Concentrations of PCBs in the sediments are also significantly lower than in the estuary, exceeding 50 ppm only in a few select areas. Sediment metals (i.e., cadmium, copper, lead, and zinc) concentrations range from a few ppm to 3,000 ppm.

The lower harbor/bay study area was divided into three areas, each having unique physical characteristics: shipchannel, shoreline, and outlying area. For the purposes of this study, these areas are defined in the following paragraphs.

The shipchannel is a contiguous area starting in the vicinity of the Butler Flats Lighthouse and extending north through the Hurricane Barrier gate, under the Route 6 swing bridge, under the Interstate 195 fixed bridge, and ending at the fixed Coggeshall Street Bridge to the north (Figure 6-3). The water depth in the shipchannel area ranges from 30 to 50 feet, which is significantly deeper than the remainder of the lower harbor/bay area. For the purposes of this study, the shipchannel area will include vessel turning basins and waterways that provide access for vessels from the shipchannel proper to adjacent docks and piers. Therefore, portions of the shipchannel area may overlap with portions of the shoreline area. This area is current lymaintained by both state and federal government programs, and is used extensively by private, commercial, and military vessels.

The shoreline area is the water-covered area directly adjacent to the shoreline at mean high tide (Figure 6-4). The water depth in this area ranges from zero to 12 feet. For this study, the shoreline area includes existing or potential development sites, piers, bridges, barriers, seagates, sluiceways, combined sewer overflows, beaches, marine parks, marinas, and other harbor-related industrial, commercial, recreational, or government properties. Portions of the shoreline area may also fall within the shipchannel area.

The outlying area is the remainder of the lower harbor/bay not included in the shipchannel or shoreline areas (Figure 6-5). The outlying area currently is not being used and is considered to have low development potential.

The shipchannel and shoreline areas, although different physically, share similarities in terms of current use and potential future use. The remedial alternative development process will consider this during alternative design so as not to compromise either current use or development potential.

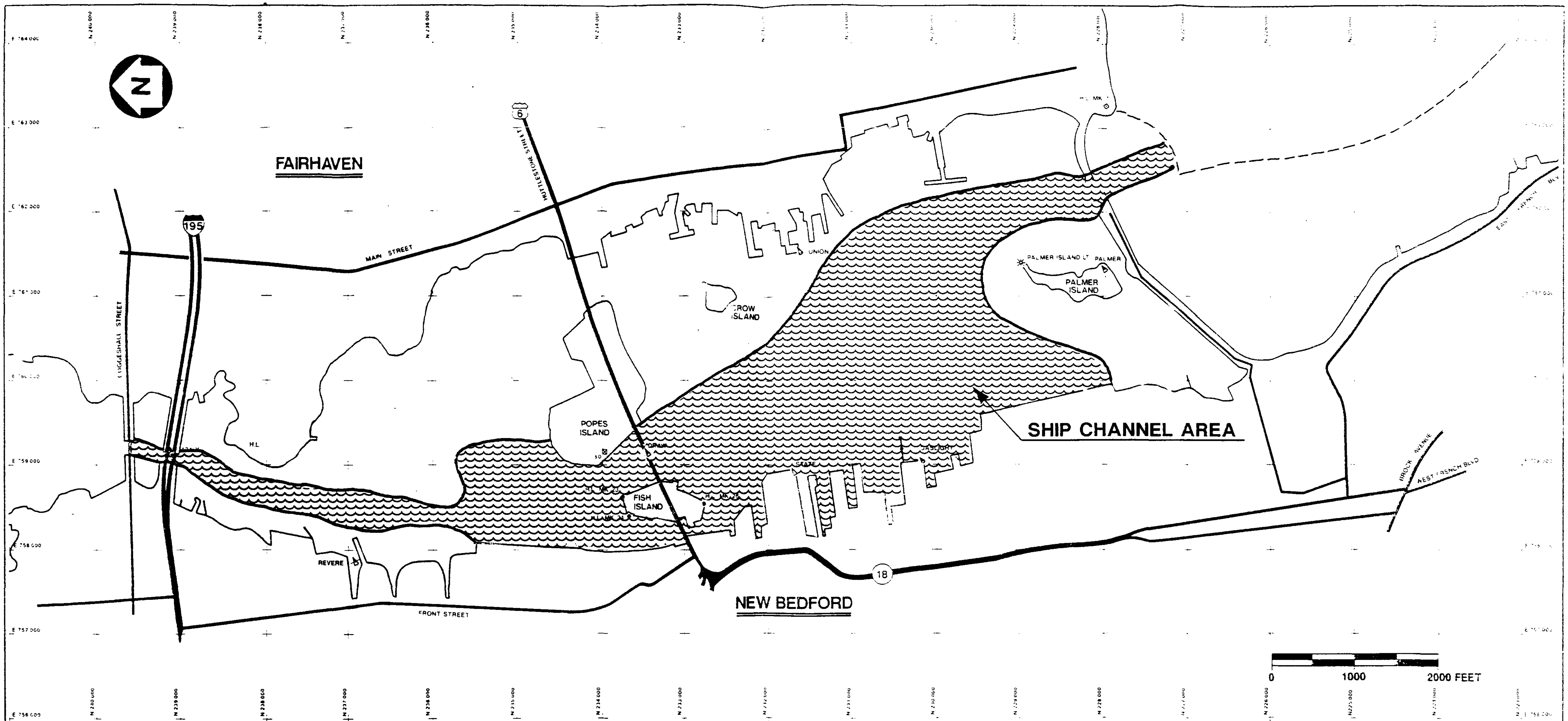


FIGURE 6-3
SHIP CHANNEL AREA
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

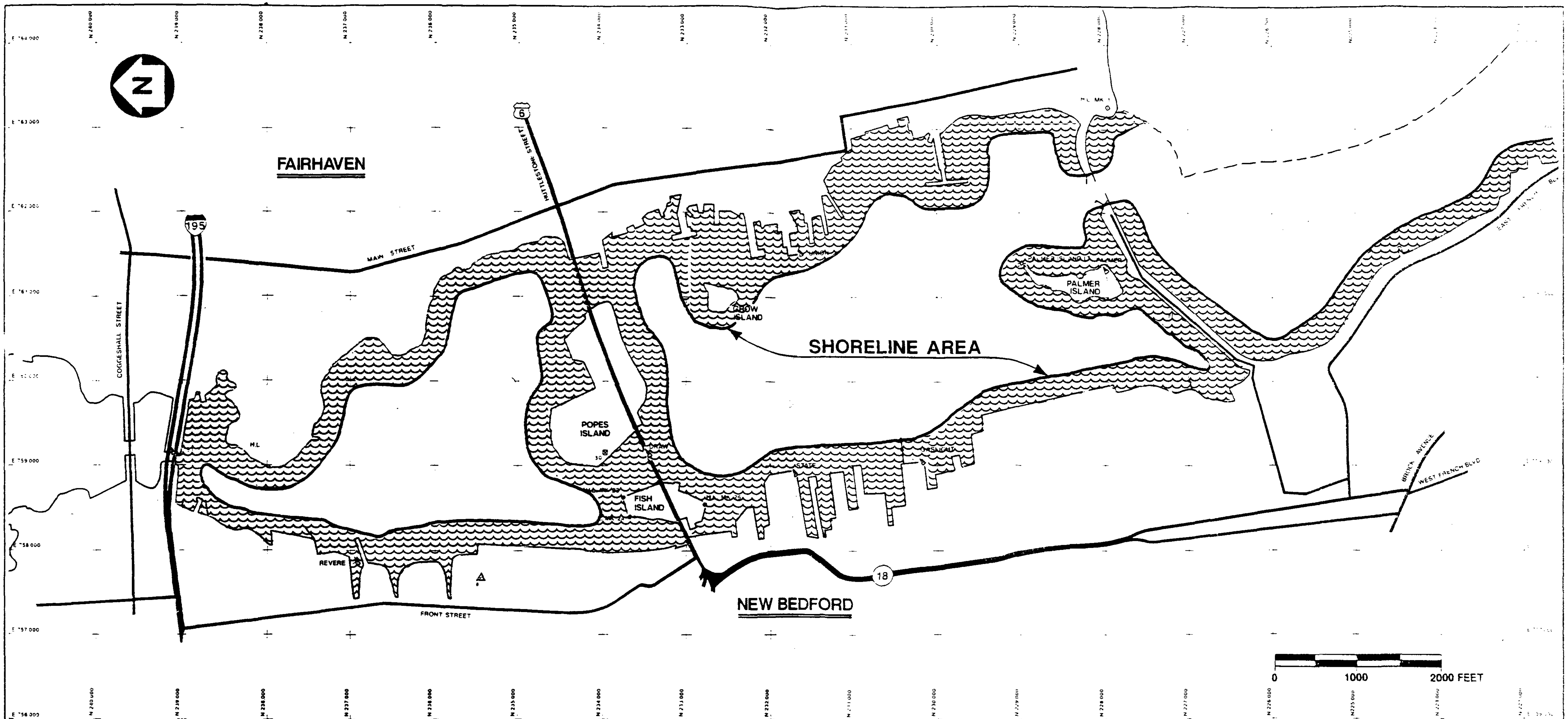


FIGURE 6-4
SHORELINE AREA
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

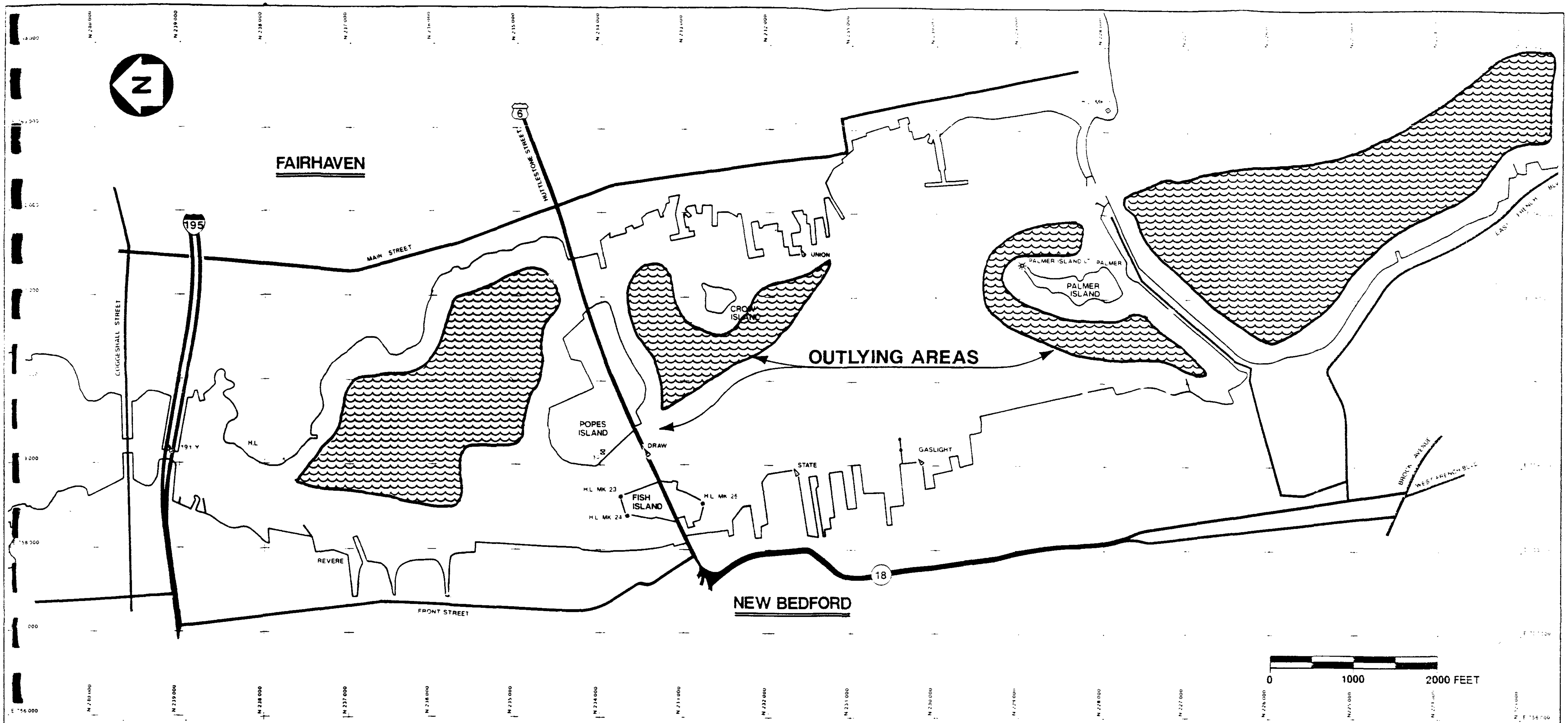


FIGURE 6-5
OUTLYING AREAS
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

Six alternatives were developed for the lower harbor/bay. Similar to the estuary alternatives, the lower harbor/bay alternatives must also achieve the 10-ppm TCL for PCBs. For the nonremoval alternatives (except no-action), approximately 250 acres of the lower harbor/bay would need to be remediated. This translates to approximately 382,000 cy of lower harbor/bay sediment that would require remediation, assuming a 1-foot depth of contamination.

Two nonremoval and four removal alternatives were developed for the lower harbor/bay. Figures 6-1 and 6-2 present a flow chart and brief descriptions of these alternatives, which are identified by the "LHB-" prefix. The no-action alternative, LHB-NA-1, serves as a baseline for comparison with the other nonremoval and removal alternatives developed for the lower harbor/bay. Alternative LHB-CONT-1 provides for on-site containment of the contaminated sediment by the placement of a granular cap over these areas requiring remediation.

The four removal alternatives involve removal of the sediment, options for treatment, and final disposal, at one or more of the different disposal locations identified for the estuary. The same range of treatment options identified for the estuary was also developed for the lower harbor/bay (i.e., no treatment, solidification, solvent extraction, and incineration). The same treatment options chosen for the estuary may also be implemented in the lower harbor/bay, although combining alternatives as such is not assumed nor necessarily appropriate. It is likely that the Record of Decision (ROD) will "mix and match" alternatives to best achieve a cost-effective solution.

6.2 CRITERIA FOR SCREENING REMEDIAL ALTERNATIVES

The remedial alternatives developed in Subsection 6.1 were screened based on the clean-up criteria described in Section 121 of SARA. The purpose of this screening step is to narrow the number of potential alternatives by considering their effectiveness, implementability, and cost, while still preserving a range of options. Specific factors considered for each criterion are described in the following subsections.

6.2.1 Effectiveness

Each alternative was evaluated for its ability to effectively protect public health and the environment and reduce the mobility, toxicity, or volume of contaminants. Both the short- and long-term effectiveness of each alternative were considered. Short-term effectiveness refers to the protection of the community and workers during implementation of remedial actions. Long-term effectiveness refers to the effectiveness of the alternative after remediation is complete.

6.2.2 Implementability

The implementability of each alternative was evaluated in terms of technical and administrative feasibility. Technical feasibility refers to the ability to construct and operate the selected technology, and to comply with action-specific ARARs. In the long-term, technical feasibility refers to the ability to operate, maintain, and monitor the technical components of the alternative. Administrative feasibility includes the ability to obtain approvals from other agencies, and the availability of services and equipment to implement the alternative.

6.2.3 Cost

To compare the different alternatives, a preliminary cost estimate was prepared for each remedial alternative. The present-worth cost of the alternative includes construction costs, operating costs for implementing the remedial action, costs for O&M for the required duration, monitoring costs, and five-year review costs (where applicable). No indirect costs or contingencies are included in these preliminary estimates; however, these costs are expected to add an extra 60 to 70 percent to the total cost.

For each alternative, a table was developed summarizing the advantages and disadvantages of that alternative with respect to effectiveness, implementability, and cost. Based on results of the screening, a decision was made to either retain the alternative for detailed evaluation or eliminate it from further consideration.

6.3 SCREENING OF REMEDIAL ALTERNATIVES FOR THE ESTUARY AND LOWER HARBOR/BAY

As identified in Subsection 6.1 and outlined in Figures 6-1 and 6-2, 14 alternatives were developed by combining applicable technologies evaluated in Section 5.0. Where appropriate, similar alternatives for the estuary and lower harbor/bay were grouped together for discussion. Each alternative developed in Subsection 6.1 was screened against criteria presented in Subsection 6.2 to determine whether it should be retained for detailed evaluation. Each alternative, an evaluation against the screening criteria, and conclusions are described in the following subsections.

6.3.1 No-Action: Alternatives EST-NA-1 and LHB-NA-1

Description. The no-action alternative for the estuary and the lower harbor/bay would involve no active remediation of these areas. However, to ensure the safety of the public, educational programs would be instituted to inform the public of the various hazards associated with the PCBs and heavy metals that exist in the sediment. Additionally, signs and fences would be maintained, as well as a continued ban on finfishing and shellfishing. Institutional controls would be required to place restrictions on future site activities and site development. These controls would be drafted, implemented, and enforced in cooperation with state and local governments.

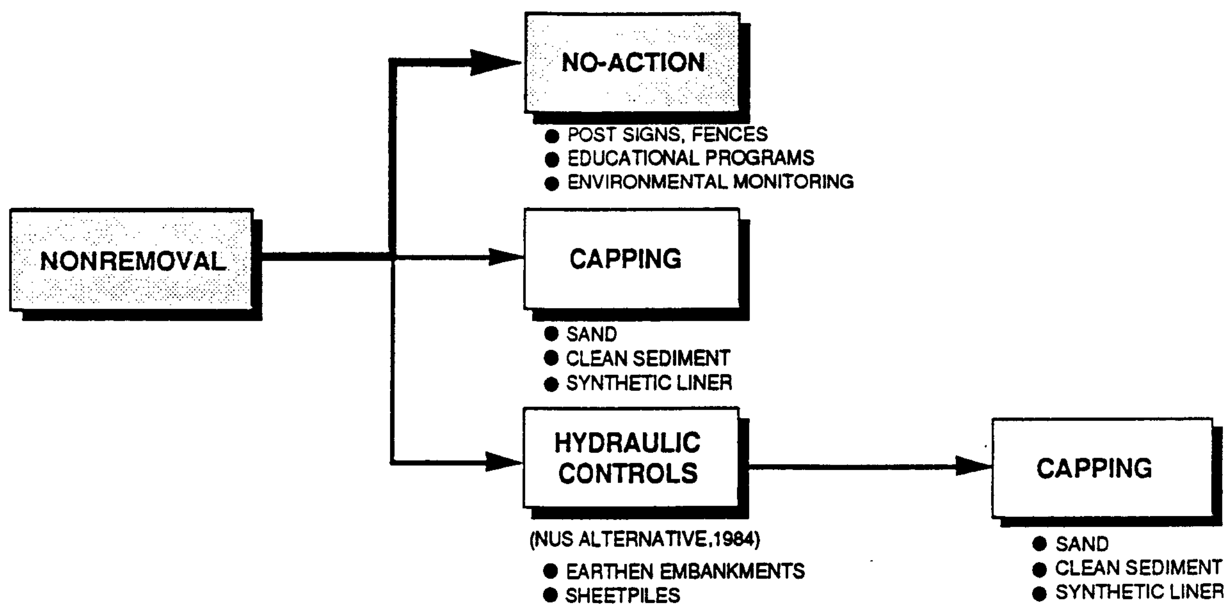
Environmental monitoring would also be conducted at prescribed intervals to determine contaminant migration, degradation, and exposure risks over time. The monitoring program should include periodic surface water and sediment sampling in the Acushnet River Estuary and the Lower Harbor. Data collected would be used to evaluate the site during the required five-year reviews, with recommendations made about the need for additional remedial actions at that time. Six reviews would be conducted over a 30-year period, as recommended in the CERCLA Remedial Investigation/FS Guidance Manual.

Screening Evaluation. The screening evaluation for Alternatives EST-NA-1 and LHB-NA-1 is summarized in Figure 6-6.

Effectiveness. The no-action alternatives would have minimal effects because the contaminants in the sediment would remain accessible to environmental receptors and transport mechanisms. There would be minimal risks associated with the installation of signs and fences because there would not be any contact with the contaminated sediment. Workers collecting samples as part of the monitoring programs would be required to wear appropriate health and safety equipment. Minimal long-term effectiveness would be realized with the no-action alternatives. Although natural processes such as biodegradation, sedimentation, and dispersion would gradually reduce the food chain exposure, no action would not significantly reduce the mobility, toxicity, or volume of the contamination. The no-action alternatives would not be protective of public health and the environment.

Implementability. The no-action alternatives would be technically easy to implement. Signs, fences, educational programs, and environmental monitoring programs are all common technologies and readily available. Opposition is expected for the no-action alternative in the estuary where sediment PCB concentrations would still range from 10 to 4,000 ppm, because significant risk remains. Because there are only a few localized areas in the harbor where the sediment exceeds 50 ppm PCBs, less opposition to the no-action alternative is anticipated for this area. The institutional controls necessary to ensure the effectiveness of these alternatives are expected to be difficult to establish and maintain. Additionally, these controls may restrict the use of shoreline areas and continue to impede shipchannel dredging in the lower harbor/bay area.

FIGURE 6-6
EST-NA-1 AND LHB-NA-1: NO-ACTION
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR



EFFECTIVENESS

Advantages

- Minimal short-term effects in implementing alternative.

Disadvantages

- Does not reduce existing risks.
- Does not prevent future exposure.
- Does not permanently or significantly reduce toxicity, mobility, or volume of PCB contamination.
- Does not protect public health or the environment.

IMPLEMENTABILITY

Advantages

- Easily implemented.
- Services and materials readily available.

Disadvantages

- Expected difficulty in obtaining approvals from other agencies.
- May restrict use of shoreline area.

COST

EST-NA-1: $3.9 million
LHB-NA-1: $3.4 million

Advantages

- Low capital and construction costs.

Disadvantages

- Continual costs for O+M of environmental monitoring systems.

Cost. The no-action alternatives would require minimal capital and construction costs; however, costs would be incurred for long-term environmental monitoring, administration associated with implementing institutional controls, and five-year reviews mandated by SARA. Indirect costs such as health and safety costs, fees, and contingencies are expected to add very little to the total cost. The present-worth costs for these alternatives are estimated to be $3.9 million for the estuary and $3.4 million for the lower harbor/bay. The costs are broken down as follows:

EST-NA-1:

Fencing	$ 280,000
Fence maintenance	215,000
Site inspections	5,000
Institutional controls	5,000
Monitoring program	3,376,000
Total	$3,881,000

LHB-NA-1:

Site inspections	$ 5,000
Institutional controls	5,000
Monitoring program	3,376,000
Total	$3,386,000

Conclusion. The no-action alternatives will be retained for detailed analysis, as required by the NCP, and will serve as a baseline for comparison of the other remedial alternatives.

6.3.2 Capping: Alternatives EST-CONT-1 and LHB-CONT-1

Description. Capping would involve covering the contaminated sediment in the estuary and select areas of the lower harbor/bay not affecting shipping traffic with a 3-foot layer of clean sediment or sand. A 3-foot-thick cap would be necessary to isolate the contaminated sediment from migration and bioturbation (USACE-NED, 1990). Approximately 187 acres in the estuary and approximately 171 acres in the lower harbor/bay would be capped.

In the estuary, the area capped in excess of the 10-ppm TCL is the result of tapering the cap material at a gradual slope from its 3-foot thickness to the natural bottom elevation of the estuary. In the lower harbor/bay, about one-third less area would be capped than defined by the 10-ppm TCL contour, because it lies in active shipping channels.

A geosynthetic liner may be used as a base for the cap material. The liner, although not impermeable, would help to prevent mixing of the clean cap with the contaminated sediment and to minimize sediment resuspension during cap placement. The geotextile would lend structual stability to the sediment under the weight of the cap.

Fine-grained granular material for the cap would be secured from local borrow pits, transported to the harbor by truck, mixed with water to form a slurry, and moved to location with a cutterhead dredge. The dredge would be moored and the material hydraulically pumped from the hopper dredge holding tanks through a submerged diffuser system and placed over the contaminated sediment.

Screening Evaluation. The screening evaluation for Alternatives EST-CONT-1 and LHB-CONT-1 is summarized in Figure 6-7.

Effectiveness. Some environmental risks are anticipated because of resuspension of contaminated sediment during cap placement. However, resuspension should be minimal because a diffuser would be used to place material. Worker safety is not considered a concern with this alternative because workers would operate from boats and would be using protective gear, thereby limiting exposure.

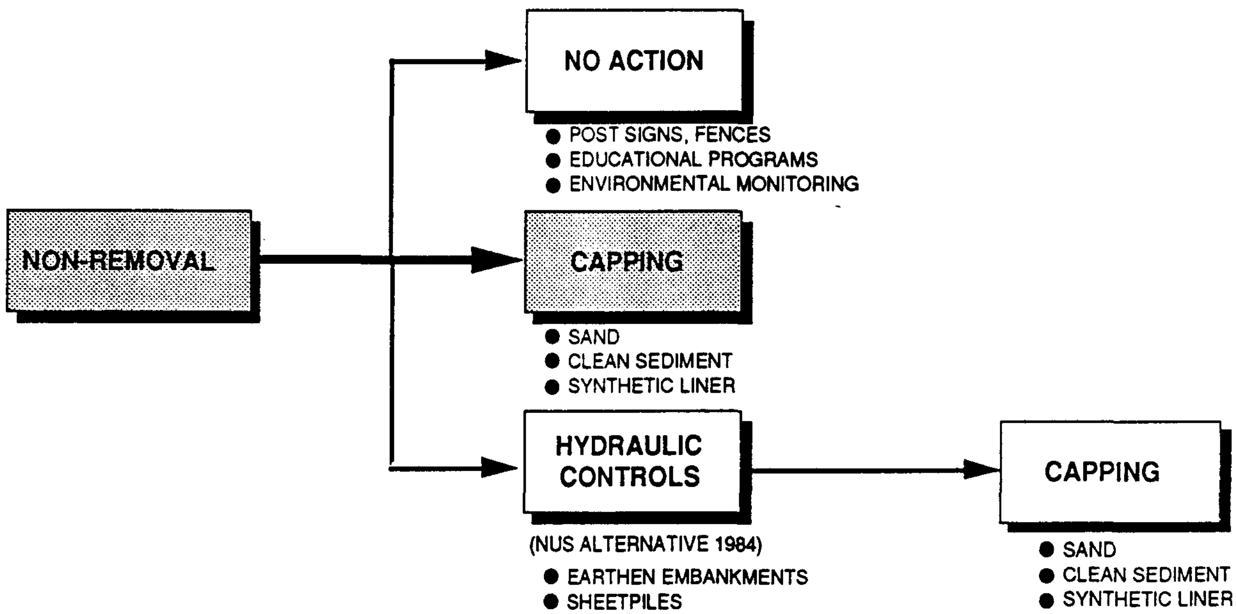
The long-term effectiveness of these alternatives is questionable because subaqueous capping of contaminated sediment, particularly in shallow water areas such as the estuary, is a relatively new application and limited performance results are available. The bearing strength of the underlying sediment may not be adequate to support a cap. Therefore, a geosynthetic liner may be required to give the sediment structural stability. Even if the cap is placed successfully, the contaminated sediment may potentially be resuspended into the water column due to hydrodynamic forces, or scouring by boat traffic in the shipchannel and shoreline areas of the lower harbor/bay. Institutional controls, frequent monitoring, and required maintenance would be necessary to maintain cap integrity.

If the cap remains intact, it may effectively reduce the transportability of PCBs and metals and prevent direct contact by biota, thereby reducing bioaccumulation. However, these contaminants are not destroyed or eliminated in the capping alternatives, and could present a risk if the cap fails.

Capping in the estuary would also significantly alter the mudflats and wetland areas due to the change in benthic topography.

Implementability. The equipment, personnel, and technologies required to implement these alternatives are readily available. However, the administrative feasibility of these alternatives is expected to be low. Institutional controls and long-term

FIGURE 6-7
EST-CONT-1 AND LHB-CONT-1: CAPPING
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR



EFFECTIVENESS

Advantages

- Reduces the bioavailability of the contaminants.
- Reduces the existing risk to public health and environment.

Disadvantages

- No reduction in mobility, toxicity, or volume of contaminants.
- Residual risk would remain.
- Some risk during implementation.
- Uncertain long-term reliability.

IMPLEMENTABILITY

Advantages

- Equipment, material , and specialists to implement alternative are readily available.

Disadvantages

- May be difficult to construct cap without disrupting hydraulic flows.
- Would impede additional remedial action, if necessary.
- Will most likely face resistance from other agencies.

COST

EST-CONT-1: $31 million
LHB-CONT-1: $28 million

Advantages

- Low development and construction costs.
- Costs for this alternative are well-defined.

Disadvantages

- Cap would require long-term maintenance.
- Would require long-term monitoring and 5-year reviews.

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monitoring programs would be needed to verify cap integrity. Because contaminated sediment is left in place, five-year review programs would need to be established over a 30-year period.

In the lower harbor/bay, the capping alternative may impede shipping traffic during implementation. If future remedial action is required, a cap in the estuary or lower harbor/bay may impede implementation of such action.

Cost. Costs for this alternative were developed assuming that the cover material is clean fill from a local borrow pit. Construction costs associated with these alternatives are for loading, transporting, and placing cap material, and for installing the geosynthetic liner and other erosion control measures. Long-term O&M costs are associated with implementation of institutional requirements, the long-term monitoring program, and mandatory five-year reviews. These alternatives are estimated to cost approximately $31 million to cap about 187 acres in the estuary, and $28 million to cap about 171 acres in the lower harbor/bay. The present worth costs are broken down as follows:

EST-CONT-1:

Hydraulic control	$ 550,000
Geotextile placement	5,084,000
Sand placement	15,683,000
Stone placement	564,000
Survey	486,000
Cap maintenance	4,825,000
Monitoring program	3,376,000
Total	$30,568,000

LHB-CONT-1:

Geotextile placement	$ 4,568,000
Sand placement	15,251,000
Survey	463,000
Cap maintenance	4,691,000
Monitoring program	3,376,000
Total	$28,349,000

The total costs are expected to increase by 60 to 70 percent when indirect costs and contingencies are considered.

Conclusion. Capping the estuary and lower harbor/bay is technically feasible. This alternative will be retained as an alternative to removing the sediment. Because the cap in the lower harbor/bay would only be used in the outlying areas, it is not expected to interfere with waterway or shoreline usage.

However, because approximately 75 acres (about 30 percent) of sediment in excess of 10 ppm remains uncovered, further remedial action would need to be taken in this area to meet the TCL. These alternatives would reduce the potential for contaminant migration; however, long-term residual risk would remain because PCBs would not be destroyed or detoxified.

6.3.3 Hydraulic Control/Capping: Alternative EST-CONT-2

Description. To accommodate the surface water discharge from the Acushnet River watershed, NUS proposed in a previous FS to construct a channel in the estuary extending from the Wood Street Bridge to the Coggeshall Street Bridge (NUS, 1984b). The river would be channelized using two earthen embankments. Contaminated sediments both within and adjacent to the channel would then be capped to a 3- to 4-foot thickness using clean sand from upland sources.

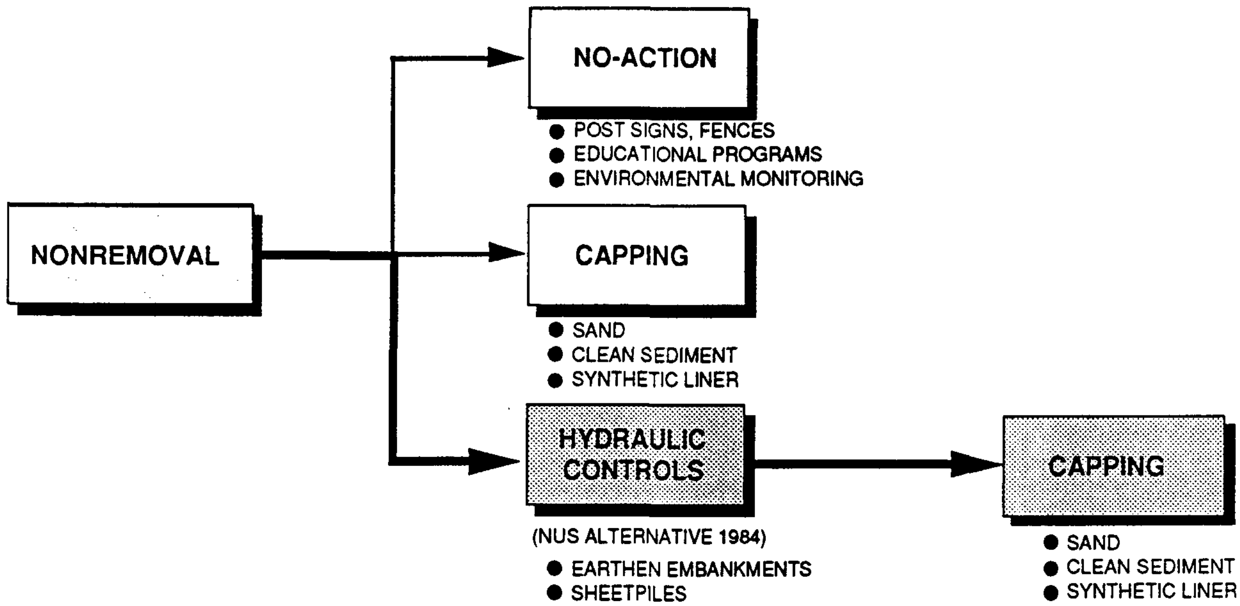
Screening Evaluation. The screening evaluation for Alternative EST-CONT-2 is summarized in Figure 6-8.

Effectiveness. PCBs may be released from the sediment during construction of the channel and embankments, causing short-term impacts to the environment. Long-term impacts would be minimized because the channel would reduce the chance of cap erosion due to hydrodynamic forces. As long as the cap and embankments remain intact, this alternative significantly reduces the transportability of the contaminants and, therefore, the bioavailability. However, this alternative does not reduce the mobility, toxicity, or volume of the contaminants and significant potential risks remain in the event of cap or embankment failure. A long-term monitoring program and five-year reviews (over a 30-year period) would be required because the contaminants would remain in place.

Implementability. This alternative is technically feasible. The technology, equipment, and trained personnel are all available. However, the cap and embankments may be difficult to construct without disrupting hydraulic flows. The cap would adversely affect existing wetlands and flood storage capacity in the estuary. This alternative may face resistance from other agencies.

Cost. Information gathered since the NUS FS has caused some alterations to the hydraulic control option. These changes are consistent with the conceptual design of the capping alternative (EST-CONT-1). Therefore, hydraulic control and geotextile placement were added and sand placement was modified to supply material from land-based sources. In addition, long-term O&M costs are associated with cap maintenance (approximately half the maintenance of straight capping) and monitoring considerations.

FIGURE 6-8
EST-CONT-2: HYDRAULIC CONTROL/CAPPING
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR



EFFECTIVENESS

Advantages

- Some reduction in bioavailability of contaminants.
- Reduces the existing risk to public health and environment.

Disadvantages

- Short-term environmental impacts due to sediment resuspension during channel construction.
- Uncertain long-term reliability in reducing transportability of contaminants.
- Residual risk would remain.
- Does not reduce mobility, toxicity, or volume of contaminants.

IMPLEMENTABILITY

Advantages

- Equipment, material, and specialists to implement alternative are readily available.

Disadvantages

- May be difficult to construct cap without disrupting hydraulic flows.
- Would adversely impact existing wetlands.
- Would impede additional remedial action, if necessary.
- Would most likely face resistance from other agencies.

COST

EST-CONT-2: $36 million

Advantages

- Development and construction costs are relatively low.

Disadvantages

- Cap would require long-term maintenance.
- Would require long-term monitoring and 5-year reviews.

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This alternative is anticipated to cost approximately $36 million at present worth. Costs are broken down as follows:

EST-CONT-2:

Hydraulic control	$ 550,000
Double embankment construction	8,431,000
Geotextile placement	5,084,000
Sand placement	15,683,000
Survey	486,000
Cap maintenance	2,412,000
Monitoring program	3,376,000
Total	$36,022,000

Similar to Alternatives EST-CONT-1 and LHB-CONT-1, an additional 60 to 70 percent increase is expected for indirect costs and contingencies.

Conclusion. Capping with hydraulic controls will be eliminated from further consideration due to its technical infeasibility. This alternative would be as effective in immobilizing the contaminants in the estuary as Alternative EST-CONT-1. However, construction of embankments and the channel may be more difficult to implement than simply capping the sediment. In addition, installation of the channel and embankments would significantly decrease flood-storage capacity in the estuary, thereby increasing the chance of flooding.

6.3.4 Dredge/On-Site Disposal/Water Treatment: Alternatives EST-DISP-1 and LHB-DISP-1

Description. These alternatives involve dredging the contaminated sediment in the estuary and the lower harbor/bay and disposing of it in island or shoreline CDFs or CAD cells. Approximately 528,000 and 382,000 cy of sediment would be removed from the estuary and the lower harbor/bay, respectively. The sediment would be transported to the disposal or handling facility by a hydraulic pipeline. If mechanical dewatering were chosen to maximize on-site disposal space and simplify sediment pumping and water treatment design schemes, the dredged sediments would be transported to a single location where a mechanical dewatering and a water treatment facility would be located. The dewatered sediments would then be transported by truck or barge to the shoreline or island disposal site.

After island or shoreline disposal, the supernatant obtained from the gravity-settling or mechanical dewatering processes would undergo water treatment for removal of the soluble and suspended contaminants present. The water treatment steps would include coagulation/flocculation, precipitation, sedimentation, filtration, and carbon adsorption. The treated water would be discharged into the harbor.

Screening Evaluation. The screening evaluation for Alternatives EST-DISP-1 and LHB-DISP-1 is summarized in Figure 6-9.

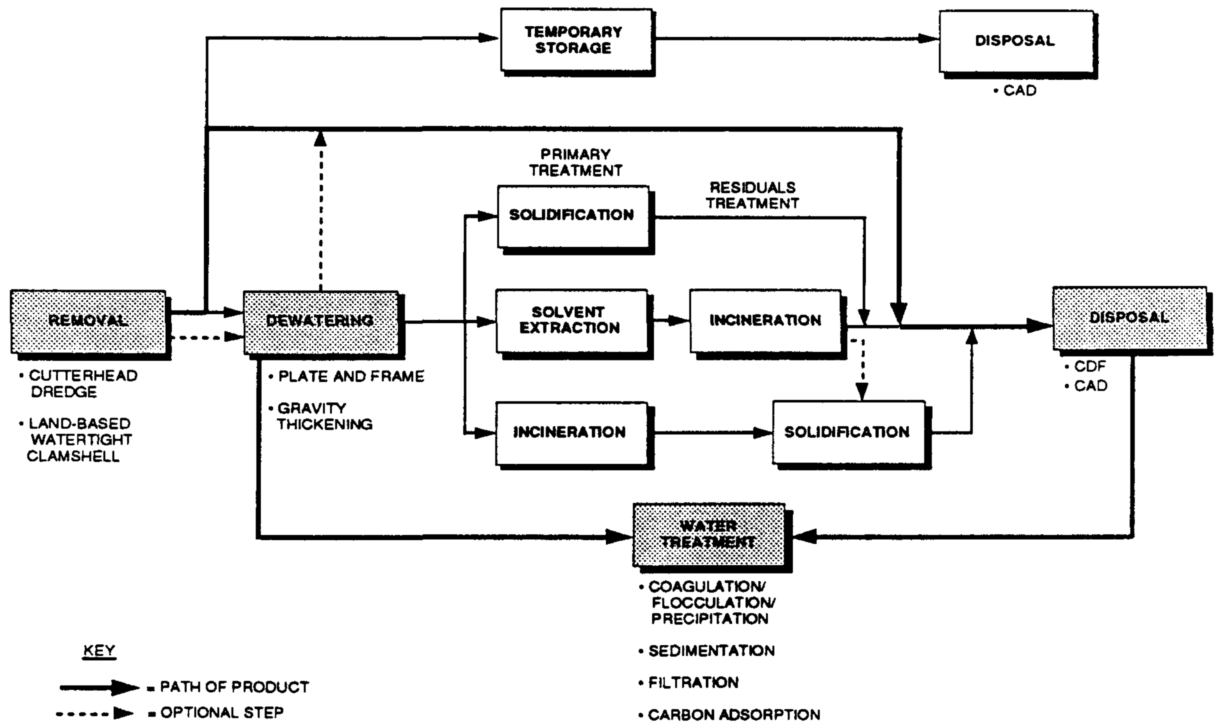
Effectiveness. Short-term effects of these alternatives would be limited to sediment resuspension and contaminant release during dredging; however, this resuspension is anticipated to be minimal based on results of the USACE pilot dredging study (see Section 5.0). Appropriate health and safety equipment would be used during removal of contaminated sediment.

The mobility, toxicity, and volume of these contaminants would not be reduced by implementing these alternatives; however, confined disposal may significantly reduce the bioavailability of the contaminants by isolating them from the environment. Leachate from the CAD, island, or shoreline disposal facilities may mobilize the contaminants, and could present a risk if the leachate enters the estuary or harbor and is not corrected and treated. Long-term monitoring would be required to assess the effectiveness of these alternatives.

Implementability. These alternatives are technically feasible. Equipment, materials, and personnel are readily available for sediment removal and construction of island, shoreline, and CAD facilities. The USACE pilot study demonstrated that these alternatives can readily be executed on a full-scale basis (see Section 5.0). Approval from other agencies is expected; however, land acquisition for disposal facilities may be difficult, and these alternatives would require significant storage capacity. Dredging complies with ARARs, but full compliance may not be achieved for the unlined disposal facilities. CAD cell maintenance, monitoring, and potential future remedial activities may not be easily undertaken. These activities would be easier to implement for the island and shoreline facilities than for the CAD cell.

Cost. Costs associated with these alternatives include sediment dredging and transport, construction of the CAD cells and CDFs, water treatment, and possibly dewatering. Long-term O&M costs include institutional controls, long-term monitoring, and costs for the five-year review. The present-worth costs of these alternatives are estimated to be $48 million to remediate 528,000 cy in the estuary and $45 million to remediate 382,000 cy in the lower harbor/bay without mechanical dewatering, and $51 million for the estuary and $47 million for the lower harbor/bay with mechanical dewatering. These costs are broken down as follows:

FIGURE 6-9
EST-DISP-1 AND LHB-DISP-1: ON-SITE DISPOSAL
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR



EFFECTIVENESS

Advantages

- May significantly reduce migration and, therefore, bioavailability of dredged contaminants (Pilot Study).
- Residual risks are considered low for CDF disposal.

Disadvantages

- Long-term risks remain because of potential leaching and migration of PCBs and other contaminants of concern from unlined CDF site(s).
- Long-term reliability uncertain.
- Mobility, toxicity, and volume of contaminants not reduced.
- Residual risk would remain.

IMPLEMENTABILITY

Advantages

- Technically feasible and proven technologies.
- Removal complies with ARARs.
- Relatively easy to undertake additional remedial action, if necessary.
- Likely to obtain agency approvals.
- Removal equipment, material, and specialists readily available.
- Equipment, material, and personnel readily available to implement construction of island, or shoreline CDF facility.

Disadvantages

- Disposal in island or shoreline facility may not comply with all ARARs.
- Island and/or shoreline disposal would displace harbor flood storage.
- Public resistance to land aquisition for CDF sites expected.

COST

EST-DISP-1: $48 million without mechanical dewatering, $51 million with mechanical dewatering.
LHB-DISP-1: $45 million without mechanical dewatering, $47 million with mechanical dewatering.

Advantages

- Implementation costs would be less than those for treatment alternatives.

Disadvantages

- Would require maintenance.
- Would require long-term monitoring and 5-year reviews.

EST-DISP-1:

	(gravity dewatering)	(mechanical dewatering)
Dredging	$ 4,119,000	$ 4,119,000
Dewater/water treatment	6,050,000	29,063,000
Material hauling	524,000	5,763,000
CDF construction	31,468,000	8,399,000
CDF maintenance	2,326,000	670,000
Monitoring program	3,376,000	3,376,000
Total	$ 47,863,000	$ 51,390,000

LHB-DISP-1:

	(gravity dewatering)	(mechanical dewatering)
Dredging	$ 3,254,000	$ 3,254,000
Dewater/water treatment	5,535,000	23,979,000
Material hauling	729,000	1,593,000
CDF construction	29,323,000	13,565,000
CDF maintenance	2,299,000	1,178,000
Monitoring program	3,376,000	3,376,000
Total	$ 44,516,000	$ 46,945,000

An additional 60 to 70 percent is expected to be added to these costs for indirect costs and contingencies.

Conclusion. These remedial alternatives are retained for detailed analysis. They would reduce the transportability of the contaminants and facilitate long-term management of the contaminated sediment. USACE conducted a pilot study to test the various components of these alternatives, including dredging, sediment transport, shoreline disposal, CAD cells, and water treatment.

Because of the bulking of sediment inherent in the dredging operation, sufficient storage space would not be available (as identified by the shoreline and island CDFs and CAD cells) if the alternative were to be carried out for both the estuary and the lower harbor/bay, unless mechanical dewatering were employed.

6.3.5 Dredge/Temporary Storage/Disposal (CAD): Alternative EST-DISP-2

Description. A second removal alternative for the estuary, identified in the NUS FS, entails dredging the sediment and disposing of it in CAD cells beneath the estuary (NUS, 1984a and

1984b). Specifically, an area of the estuary would be dredged and the sediment stored temporarily. The clean sediment beneath the previously dredged area would then be removed to a predetermined depth, forming a depression or cell in the bottom of the estuary. The clean sediment removed from this area would be stored temporarily. Contaminated sediment in an area adjacent to the cell would then be removed and deposited into the CAD cell. The clean material removed beneath the dredged sediment in the second area would be used to cover the first area. This sequence would continue until the desired area of contaminated sediment was removed. The final cell would be filled with spoils from the first area and covered with the temporarily stored clean sediment from that same first area. This method of disposal was evaluated by USACE during its pilot study.

Screening Evaluation. The screening evaluation for Alternative EST-DISP-2 is summarized in Figure 6-10.

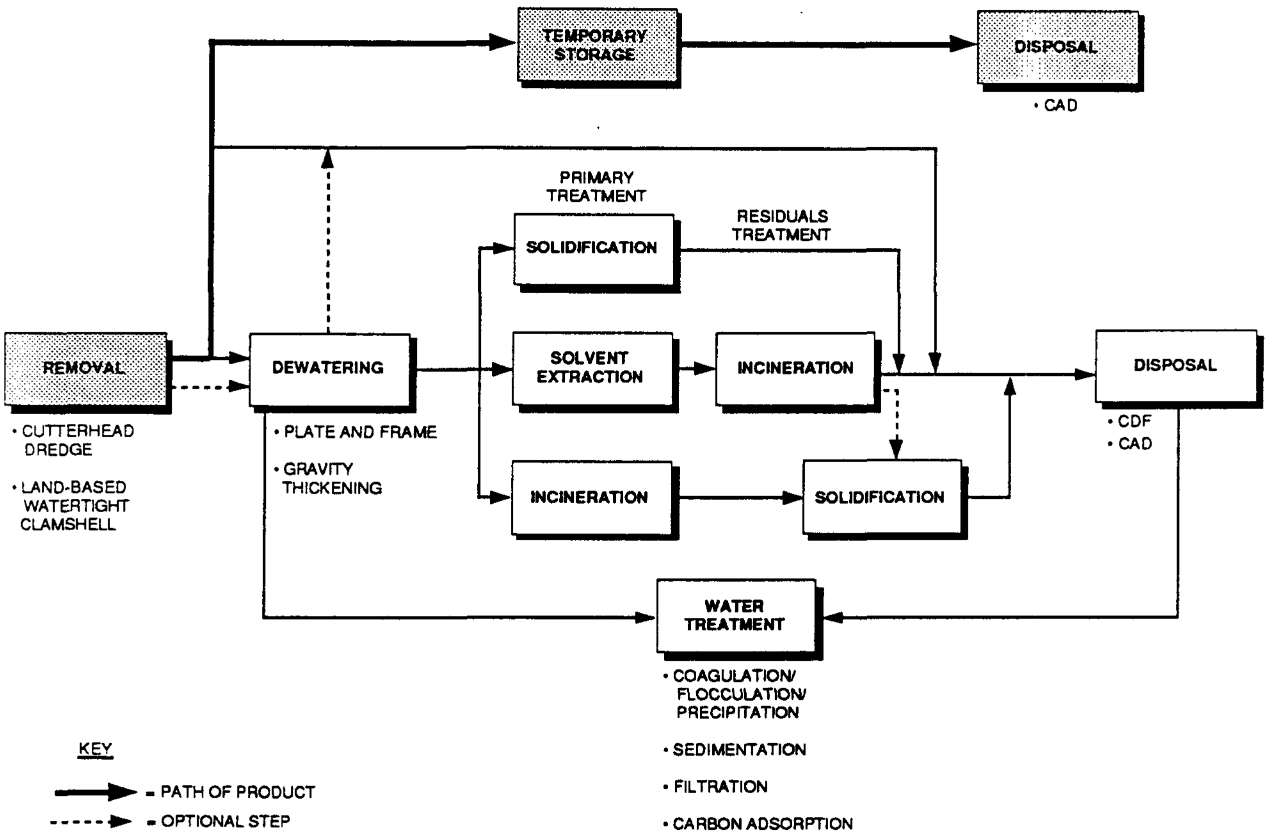
Effectiveness. The pilot study results show that a cutterhead dredge can remove the contaminated sediment while minimizing resuspension and contaminant release. Disposal of contaminated material into the CAD cell will result in elevated levels of suspended solids and contaminants in the water in close proximity to the operations; however, monitoring carried out at the Coggeshall Street Bridge did not detect any increased movement of contaminants into the lower harbor.

Short-term impacts to workers, the community, and the environment should be minimal because limited contact with the dredged material is anticipated. An air monitoring program would be needed to verify compliance with PCB air standards.

The long-term effectiveness of this alternative is unknown due to a lack of historical data. CAD cells for the containment of contaminated sediment have been constructed in only a few sites, including the Duwamish Waterways in Seattle, Washington, and Rotterdam Harbor in the Netherlands (see Section 5.0). As with the containment alternatives, there is no reduction in the mobility, toxicity, or volume of the PCB-contaminated sediment. The contaminants remain within the estuary and are subject to release into the water column due to natural or manmade disturbances. A long-term monitoring program would need to be established to monitor effectiveness of this alternative.

Implementability. The use of CAD cells is an innovative approach to disposing of or containing contaminated sediment. As discussed previously, this technology was pilot-tested by USACE and proven to be technically feasible for New Bedford Harbor sediment. Equipment and personnel capable of constructing CAD cells and temporary CDF cells are available. However, USACE determined that much of the estuary is unsuitable for CAD cell development, either because of unfavorable hydrodynamics (i.e.,

FIGURE 6-10
EST-DISP-2: DREDGE/DISPOSE CAD
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR



EFFECTIVENESS	IMPLEMENTABILITY	COST

EFFECTIVENESS

Advantages

- Significantly reduces transportability and, therefore, bioavailability of contaminants (Pilot Study).
- Reduces existing risk to public health and environment.

Disadvantages

- Does not reduce mobility, toxicity, or volume of contaminants.
- Leachate may enter estuary with time.
- Short-term risks due to potential sediment resuspension.
- Long-term risks uncertain.
- Residual risk would remain.

IMPLEMENTABILITY

Advantages

- Technically feasible
- Equipment, material, and specialists readily available.
- Complies with location-specific ARARs.

Disadvantages

- Difficult to undertake additional remedial action, if necessary.
- Most of estuary unsuitable for CAD development.

COST

EST-DISP-2: $82 million

Advantages

- Low capital and construction costs compared to treatment alternatives.

Disadvantages

- Would require maintenance.
- Would require long-term monitoring and 5-year reviews.

high water velocities resulting in scouring and insufficient water depth) or unsuitable benthic topography (Averett and Palermo, 1988). For these reasons, much of the area NUS identified for sediment disposal in CAD cells is not suitable.

The CAD alternative does not remove or treat PCB-contaminated sediment. Monitoring, institutional controls, and five-year reviews over a period of 30 years would be required to verify the long-term effectiveness of this alternative and to minimize disturbances to these cells. Future remedial action, if necessary, may be difficult to implement.

This alternative is expected to comply with wetlands location-specific ARARs because minimal disturbances to the wetlands are expected during implementation of this alternative. CAD cell construction would not permanently alter the shoreline or estuary bathymetry.

<u>Cost</u>. Costs associated with this alternative include construction costs for dredging the CAD cells, construction costs for creating temporary storage space, and long-term costs associated with implementation of institutional controls, long-term monitoring, and the six mandatory five-year reviews. The estimated present worth cost of this alternative is approximately $82 million. The cost is broken down as follows:

<u>EST-DISP-2:</u>

Dredging	$ 9,335,000
Water treatment	7,488,000
Material hauling	197,000
Temporary CDF construction	38,688,000
Material replacement	22,562,000
Monitoring program	3,376,000
Total	$81,646,000

An additional 60 to 70 percent is expected to be added to the cost for indirect costs and contingencies.

<u>Conclusion</u>. Because much of the estuary is unsuitable for CAD cell construction, and all the available shoreline and island space would be needed for temporary CDF cells, this disposal technology will be eliminated as a separate alternative. However, the CAD technology will be retained and may be incorporated in conjunction with the shoreline and/or island CDF disposal alternatives.

6.3.6 Remove Sediments/Dewater/Treat Water/Solidify Dewatered Sediments/On-site Disposal: Alternatives EST-TREAT-1 and LHB-TREAT-1

Description. These removal alternatives involve a sediment treatment step. Approximately 528,000 and 382,000 cy would be dredged in the estuary and the lower harbor/bay (respectively) to achieve the 10-ppm TCL. The dredged slurry would be transported hydraulically to a shoreline dewatering facility for mechanical dewatering. The water from the dewatering process would undergo several treatment steps, including coagulation/flocculation, precipitation, sedimentation, filtration, and carbon adsorption or UV/oxidation, prior to being discharged in the harbor. The dewatered sediment (approximately 50 percent solids) would be chemically fixed to bind the PCBs and metals present, thereby reducing mobility of the contaminants. The solidified sediments would be disposed of in an on-site CDF without additional treatment.

Screening Evaluation. The screening evaluation for Alternatives EST-TREAT-1 and LHB-TREAT-1 is summarized in Figure 6-11.

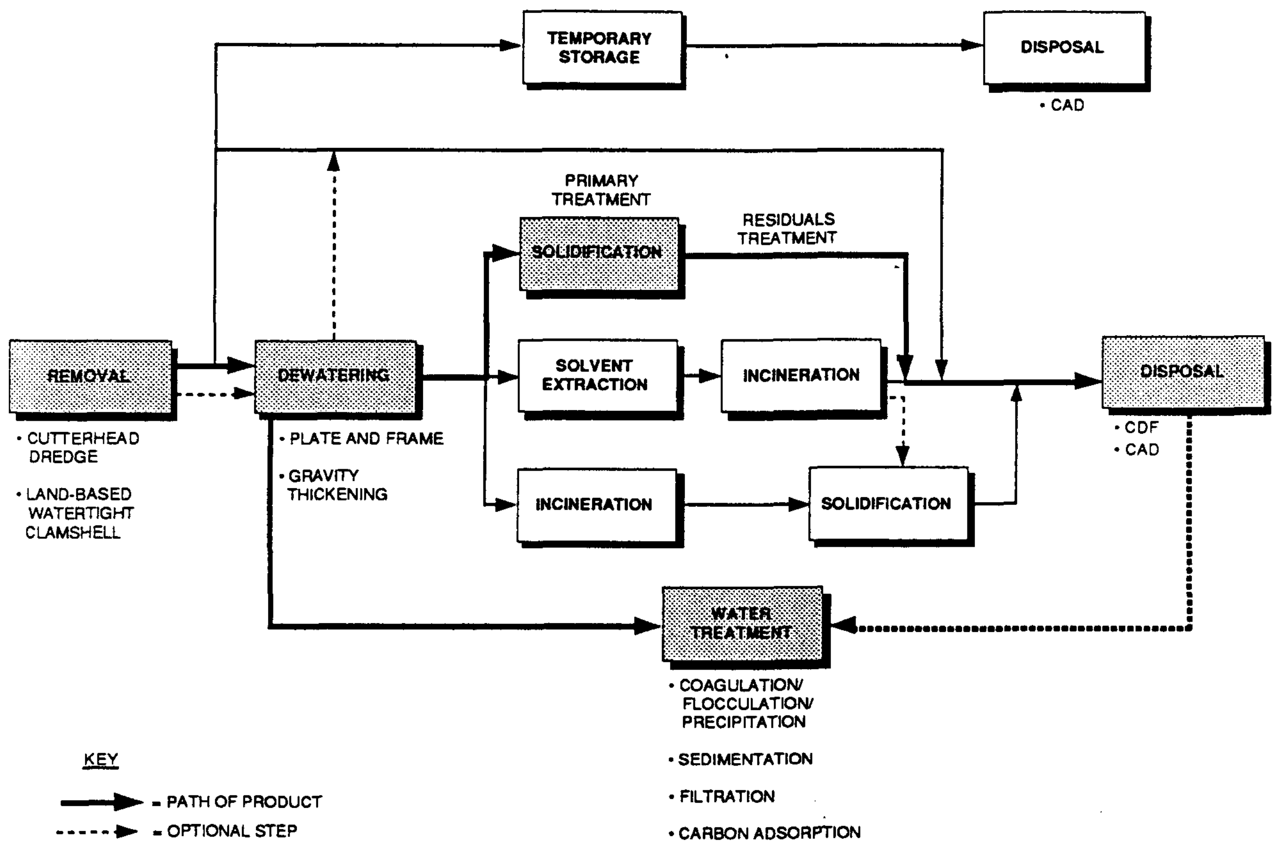
Effectiveness. As with the other dredging alternatives, minimal short-term effects are anticipated due to dredging. Appropriate health and safety equipment will be used during removal and treatment of contaminated sediment.

Bench-scale tests by USACE showed that PCB mobility can be reduced by 80 to 90 percent by solidifying the sediment in a controlled environment. These alternatives permanently reduce the mobility of the PCBs and metals; however, the volume of contaminated sediment would be increased approximately 25 percent through solidification. Long-term monitoring and five-year reviews over a 30-year period would be required for these alternatives because PCB-contaminated sediment below the 10-ppm TCL would still remain in the harbor.

Implementability. These alternatives are technically feasible. Equipment and trained personnel are readily available to dredge, dewater, and transport the sediment, and to construct the CDFs. Solidification has been used for treating PCB-contaminated soil and several vendors are available to perform the solidification process. Implementation of these alternatives would require coordination with other federal and state agencies. The volume increase would require significant CDF space, which may affect harbor flood storage capacity. In addition, land will need to be acquired to site the CDFs previously identified.

Cost. Costs associated with these alternatives include dredging and transport, construction of CDFs, water treatment, dewatering, solidification, and monitoring. The total present worth cost of these alternatives is estimated to be approximately $98 million

FIGURE 6-11
EST-TREAT-1 AND LHB-TREAT-1: DREDGE/SOLIDIFY/DISPOSE
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR



EFFECTIVENESS

Advantages

- Permanent and significant reduction in mobility of PCBs and metals; increase in volume.
- Would reduce existing and long-term risk associated with the contaminated sediment.
- Minimal short-term risk.

Disadvantages

- Uncertain long-term reliability of solidification.
- Residual risk would remain.

IMPLEMENTABILITY

Advantages

- Technically feasible
- Equipment, material, and specialists are readily available.

Disadvantages

- Would require coordination with several other federal and state agencies.
- CDF space required may affect harbor flood storage capacity.

COST

EST-TREAT-1: $98 million.
LHB-TREAT-1: $81 million.

Advantages

- Solidification costs less than other treatment alternatives.

Disadvantages

- Would require long-term monitoring and 5-year reviews.

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to solidify approximately 528,000 cy of estuary sediment, and $81 million to solidify 382,000 cy of sediment in the lower harbor/bay. These costs are broken down as follows:

EST-TREAT-1:

Dredging	$ 4,119,000
Dewater/water treatment	29,063,000
Material hauling	6,287,000
Sediment treatment	42,639,000
CDF construction	11,533,000
CDF maintenance	862,000
Monitoring program	3,376,000
Total	$97,879,000

LHB-TREAT-1:

Dredging	$ 3,254,000
Dewater/water treatment	23,979,000
Material hauling	2,007,000
Sediment treatment	33,681,000
CDF construction	13,565,000
CDF maintenance	1,178,000
Monitoring program	3,376,000
Total	$81,040,000

It is expected that the costs of these alternatives will increase 60 to 70 percent due to indirect costs and contingencies.

Conclusion. These remedial alternatives are retained for detailed analysis due to their effectiveness and implementability. Solidification would immobilize the contaminants present. USACE determined that various mixes of cement and additives have achieved better than 90 percent effectiveness in immobilizing the PCBs. On-site disposal was chosen over off-site disposal because of statutory preference for on-site containment and because of the high cost:benefit ratio of off-site disposal.

6.3.7 Dredge/Dewater/Treat Water/Solvent Extraction of Dewatered Sediment/On-site Disposal: Alternatives EST-TREAT-2 and LHB-TREAT-2

Description. These alternatives are similar to EST-TREAT-1 and LHB-TREAT-1. The solidification technology is replaced by an organic solvent extraction process to remove the PCBs. The extract containing PCBs/oils would be incinerated on-site. If the residual sediment exhibits metals leaching in excess of EP

Toxicity/TCLP criteria, these residuals would be solidified. The treated sediment would be disposed of in shoreline CDFs. Water would be treated as described in Alternatives EST-TREAT-1 and LHB-TREAT-1.

Screening Evaluation. The screening evaluation for Alternatives EST-TREAT-2 and LHB-TREAT-2 is summarized in Figure 6-12.

Effectiveness. As with other dredging alternatives, minimal short-term effects are anticipated due to dredging. Appropriate health and safety equipment will be used during removal and treatment of contaminated sediment.

These alternatives are expected to be effective in permanently reducing the mobility, toxicity, and volume of the contaminants in the sediment. A bench-scale test on sediment from the estuary and Hot Spot areas showed that greater than 99 percent of the PCBs can be removed from the sediment. Solidification is expected to effectively immobilize the metals left after solvent extraction, if the residual sediment shows the potential for leaching metals in excess of the EP Toxicity/TCLP criteria. Incineration of the organic residual will permanently destroy the PCBs. Because these alternatives would not remove and treat PCB-contaminated sediment at concentrations below 10 ppm, long-term monitoring, institutional controls, and five-year reviews would be required over a 30-year period.

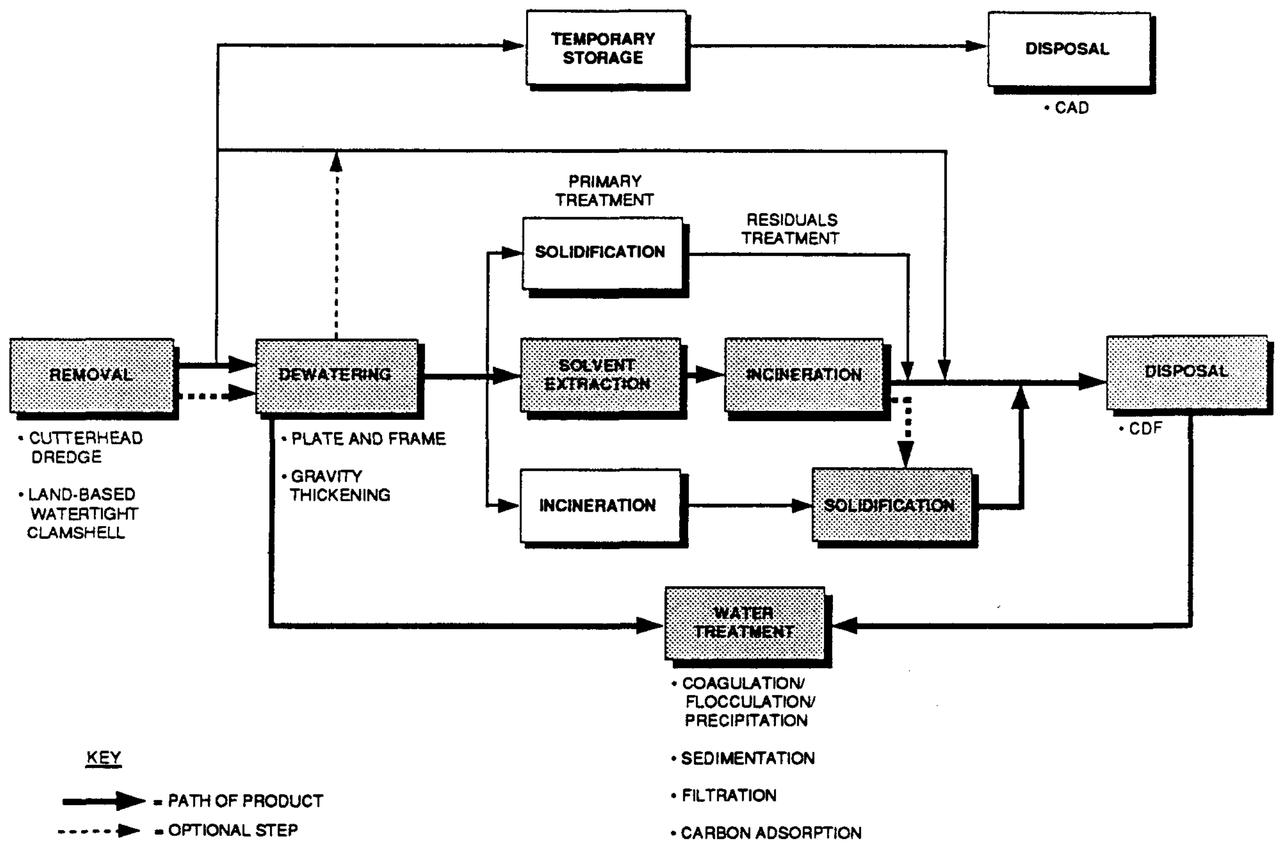
Implementability. Equipment and trained personnel are readily available to dredge, dewater, transport, and solidify (if necessary) the sediments, and to construct CDFs. At least two vendors have solvent extraction systems that will be available for full-scale operation in the near future. Implementation of this alternative would require coordination with several other federal and state agencies.

Cost. Costs associated with these alternatives include dredging and transport of sediments, construction of CDFs, water treatment, dewatering, solvent extraction, incineration of the extract, and solidification of the residual sediment. The cost of these alternatives is estimated to be $156 million to remediate 528,000 cy of sediment in the estuary and $127 million to remediate 382,000 cy in the lower harbor/bay. These costs are broken down as follows:

EST-TREAT-2:

Dredging	$ 4,119,000
Dewater/water treatment	29,063,000
Material hauling	586,000
Sediment treatment	116,199,000

FIGURE 6-12
EST-TREAT-2 AND LHB-TREAT-2: DREDGE/SOLVENT EXTRACT/ TREAT RESIDUALS/DISPOSE
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR



EFFECTIVENESS

Advantages

- Permanent and significant reduction in mobility, toxicity, or volume of PCBs and metals.
- Reduces existing and long-term risk to public health and environment.
- Minimal short-term impacts.

Disadvantages

- This new technology has been demonstrated at only a few sites.
- Residual risk would remain.

IMPLEMENTABILITY

Advantages

- Innovative technology; bench-scale tests performed on New Bedford Harbor sediment.
- Equipment available.

Disadvantages

- Would require coordination with several other federal and state agencies.

COST

EST-TREAT-2: $156 million.
LHB-TREAT-2: $127 million.

Advantages

- Less expensive than incineration of sediment.

Disadvantages

- Higher costs anticipated; unproven technology.
- Would require long-term monitoring and 5-year reviews.

EST-TREAT-2:

CDF construction	2,239,000
CDF maintenance	199,000
Monitoring program	3,376,000
Total	$155,781,000

LHB-TREAT-2:

Dredging	$ 3,254,000
Dewater/water treatment	23,979,000
Material hauling	463,000
Sediment treatment	91,953,000
CDF construction	4,089,000
CDF maintenance	318,000
Monitoring program	3,376,000
Total	$127,432,000

A 60 to 70 percent increase in these costs is expected when indirect costs and contingencies are considered.

Conclusion. These alternatives will be retained for detailed analysis. These alternatives represent a mid-range treatment option utilizing an innovative technology. Bench-scale testing has shown that this technology is effective in removing PCBs from New Bedford Harbor sediment.

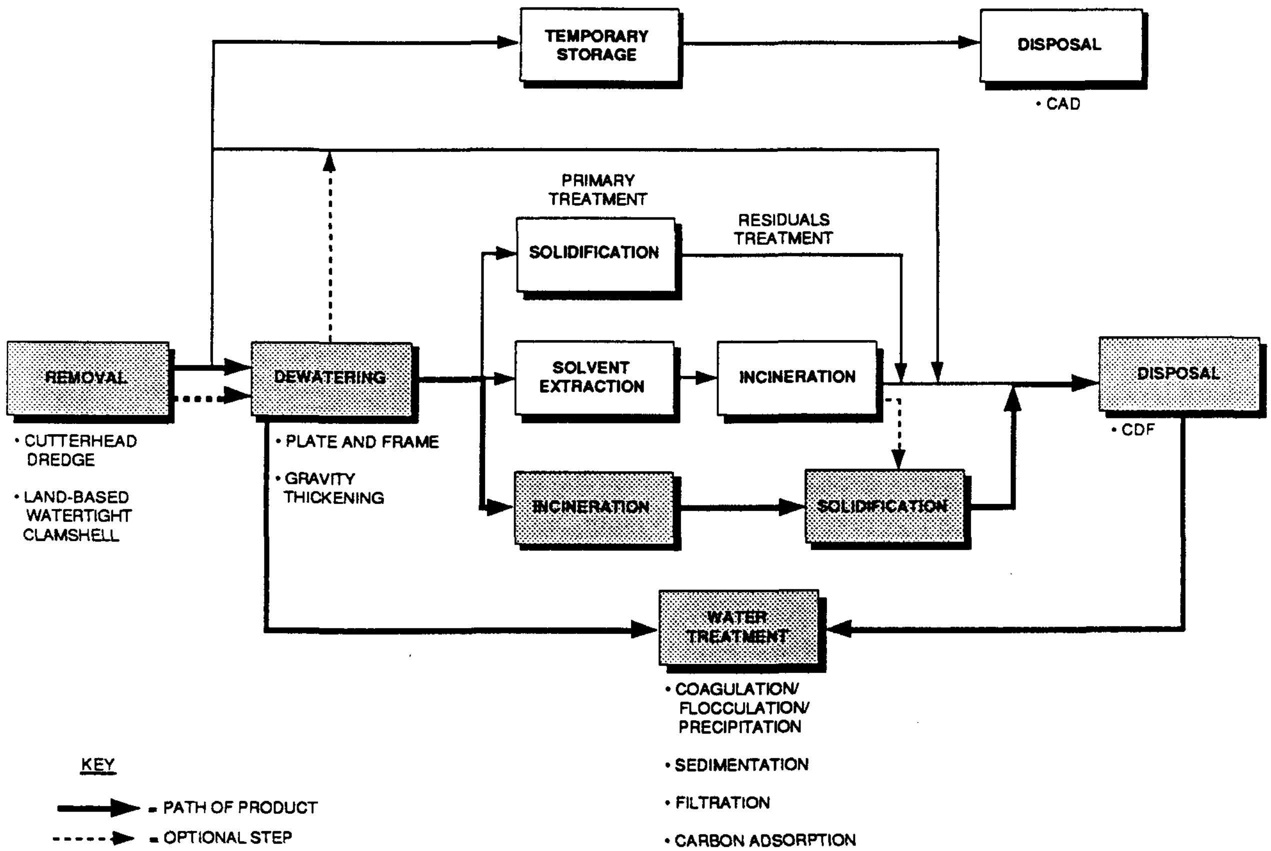
6.3.8 Remove Sediments/Dewater/Treat Water/Thermally Treat Dewatered Sediments/Treat Process Residuals/On-site Disposal: Alternatives EST-TREAT-3 and LHB-TREAT-3

Description. These alternatives are similar to Alternatives EST-TREAT-2 and LHB-TREAT-2. The exception is that the dewatered sediment would be thermally treated to destroy the PCBs instead of the PCBs being extracted from the sediment first. The sediments would be dredged, transported to a shoreline dewatering facility, and dewatered. The water from the dewatering process would be treated on-site, as described in earlier removal alternatives. The dewatered sediment would be incinerated, followed by solidification (if necessary) to bind the oxidized metals and reduce metals leachability. The treated sediments would then be disposed of in on-site CDFs.

Screening Evaluation. The screening evaluation for Alternatives EST-TREAT-3 and LHB-TREAT-3 is summarized in Figure 6-13.

Effectiveness. As with other dredging alternatives, minimal short-term effects are anticipated due to dredging. Appropriate health and safety equipment will be used during removal and

FIGURE 6-13
EST-TREAT-3 AND LHB-TREAT-3: DREDGE/INCINERATE/ TREAT RESIDUALS/DISPOSE
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR



EFFECTIVENESS

Advantages

- Permanent and significant reduction in volume, toxicity, and mobility of hazardous waste.
- Reduces existing and long-term risk to public health and environment.

Disadvantages

- Potential short-term risks associated with incinerator operation.

IMPLEMENTABILITY

Advantages

- Proven technology; high technical feasibility.
- Equipment readily available.
- Complies with action-specific ARARs.

Disadvantages

- Would require coordination with other agencies.

COST

EST-TREAT-3: $194 million
LHB-TREAT-3: $158 million

Advantages

- None

Disadvantages

- More expensive than other technologies being considered.
- Would require long-term monitoring and 5-year reviews.

treatment of contaminated sediment. Potential short-term risks are associated with the operation of the on-site incinerator.

These alternatives would permanently reduce the toxicity, mobility, and volume of the contaminants in the sediment by removing them from the estuary and harbor and destroying them by incineration. Incineration is a proven treatment technology for PCBs, and achieves greater than 99 percent PCB destruction efficiency. Solidification of the ash is expected to effectively immobilize the metals remaining after incineration. Because these alternatives would not remove and treat PCB-contaminated sediment at concentrations below 10 ppm, long-term monitoring, institutional controls, and five-year reviews would be required for a 30-year period.

Implementability. These alternatives are technically feasible. Equipment and trained personnel are readily available to dredge, dewater, transport, incinerate, and solidify the sediment, and to construct CDFs. Incineration is a proven technology for PCB destruction. It is consistent with the SARA preference for permanent treatment, and it would comply with TSCA and other action-specific ARARs. Implementation of these alternatives would require coordination with other agencies.

Cost. Costs associated with these alternatives include dredging and transport, construction of CDFs, water treatment, dewatering, incineration, and solidification. The cost of these alternatives is estimated to be $194 million to remove and incinerate 528,000 cy of estuary sediment and $158 million to remediate 382,000 cy of sediment in the lower harbor/bay. These costs are broken down as follows:

EST-TREAT-2:

Dredging	$ 4,119,000
Dewater/water treatment	29,063,000
Material hauling	586,000
Sediment treatment	154,780,000
CDF construction	2,239,000
CDF maintenance	199,000
Monitoring program	3,376,000
Total	$194,362,000

LHB-TREAT-2:

Dredging	$ 3,254,000
Dewater/water treatment	23,979,000
Material hauling	463,000
Sediment treatment	122,263,000

LHB-TREAT-2:

CDF construction	4,089,000
CDF maintenance	318,000
Monitoring program	3,376,000
Total	$157,742,000

An increase of 60 to 70 percent is expected due to indirect costs and contingencies.

Conclusion. These alternatives were retained for detailed analysis because incineration has been proven highly effective in treating PCBs. Solidification is also a proven method of binding metals in residual ash, if necessary.

6.4 SCREENING SUMMARY

Presented in the following subsections are those alternatives that will be retained and evaluated in detail. These alternatives represent a range in ability to reduce mobility, toxicity, or volume of the contaminants with various degrees of cost effectiveness.

6.4.1 Estuary

The screening evaluation for the estuary remedial alternatives is summarized in the following table. Of the eight alternatives developed for the estuary, six will be retained for detailed analysis. These six alternatives have been renumbered for discussion during the detailed evaluation.

ORIGINAL ALTERNATIVE NUMBER	NEW ALTERNATIVE NUMBER	ALTERNATIVE DESCRIPTION
EST-NA-1	EST-1	No-action
EST-CONT-1	EST-2	Capping
EST-DISP-1	EST-3	Dredge/Dispose On-site
EST-TREAT-1	EST-4	Dredge/Dewater/Solidify/Dispose On-site
EST-TREAT-2	EST-5	Dredge/Dewater/Solvent Extract/ Dispose On-site
EST-TREAT-3	EST-6	Dredge/Dewater/Incinerate/ Solidify Ash/Dispose On-site

6.4.2 Lower Harbor/Bay

The following table summarizes results of the alternatives screening for the lower harbor/bay. Six alternatives were developed for initial screening, and all were retained for detailed analysis. The remedial alternatives for the lower harbor/bay were renumbered for discussion during the detailed evaluation.

ORIGINAL ALTERNATIVE NUMBER	NEW ALTERNATIVE NUMBER	ALTERNATIVE DESCRIPTION
LHB-NA-1	LHB-1	No-action
LHB-CONT-1	LHB-2	Selective Capping
LHB-DISP-1	LHB-3	Dredge/Dispose On-site
LHB-TREAT-1	LHB-4	Dredge/Dewater/Solidify/Dispose On-site
LHB-TREAT-2	LHB-5	Dredge/Dewater/Solvent Extract/ Dispose On-site
LHB-TREAT-3	LHB-6	Dredge/Dewater/Incinerate/Dispose On-site

7.0 DETAILED ANALYSIS OF ALTERNATIVES

7.1 INTRODUCTION

The detailed analysis of alternatives is intended to provide decision-makers with sufficient information to select a remedy from the range of proposed remedial actions that meets the following CERCLA requirements:

- o is protective of public health and the environment
- o attains ARARs (or provides grounds for invoking a waiver)
- o is cost-effective
- o is a permanent solution that uses treatment technologies or resource recovery techniques to the maximum extent practicable
- o has preference for treatment that reduces mobility, toxicity, or volume as a principal element

Section 7.0 is a detailed evaluation of the six estuary and the six lower harbor/bay alternatives that passed the screening process described in Section 6.0. Each alternative evaluation includes a detailed description emphasizing the technologies used, specific components, and proposed design specifications. Anticipated work activities are summarized and graphics are included to depict treatment process flows and equipment. Descriptions of remedial alternatives for the estuary and the lower harbor/bay are combined where applicable. The description of each alternative is followed by an assessment of the alternative with respect to the following nine CERCLA evaluation criteria:

- o short-term effectiveness
- o long-term effectiveness and permanence
- o reduction of mobility, toxicity, or volume of wastes
- o implementability
- o cost
- o compliance with ARARs
- o overall protection of public health and the environment
- o state acceptance
- o community acceptance

The first five criteria address technical, cost, institutional, and risk concerns. Compliance with ARARs and overall protection of public health and the environment are threshold criteria that reflect statutory requirements. The final two criteria, state and community acceptance, were evaluated on the basis of information available at the time of the detailed analysis.

State and community acceptance are addressed once and apply to each alternative retained.

State Acceptance. EPA has maintained continuous communications with Massachusetts state agencies (e.g., MADEP and CZM) during the New Bedford Harbor project. Representatives of these state agencies attended monthly status meetings held by EPA and commented on most of the interim reports (including drafts of this document) issued by EPA's contractors. Comments made by these state agencies will be incorporated into the Responsiveness Summary as part of the ROD process.

Community Acceptance. A Community Work Group has been created to keep members of the community informed of progress at the site. The group meets on a monthly basis to discuss the project; however, it has not formally responded to the proposed remedial actions for the estuary and the lower harbor/bay. The community will have a 30-day public comment period following release of the draft final FS to make formal comments. Comments received at that time will be incorporated into the Responsiveness Summary, as part of the ROD process.

7.2 ALTERNATIVES EST-1 AND LHB-1: NO-ACTION

7.2.1 General Description

Development of a no-action alternative is required under the NCP. The no-action alternative serves as the baseline remedial alternative, which assesses impacts on public health and the environment if no measures are taken to remediate current site conditions. However, as a minimum, the no-action alternative for the estuary and the lower harbor/bay may include administrative/institutional controls to reduce the potential for exposure to site contaminants (Figure 7-1).

The no-action alternative for both the estuary and the lower harbor/bay areas would not involve any direct activities (e.g., dredging and treatment) conducted to remediate the PCB- and metals-contaminated sediment. Instead, the no-action alternative would consist of administrative and institutional controls to minimize human exposure to the contaminated sediment, including the following:

- o warning signs posted
- o installation of a chainlink fence in easily accessible areas
- o establishment of institutional controls
- o environmental monitoring of the estuary and the lower harbor/bay system

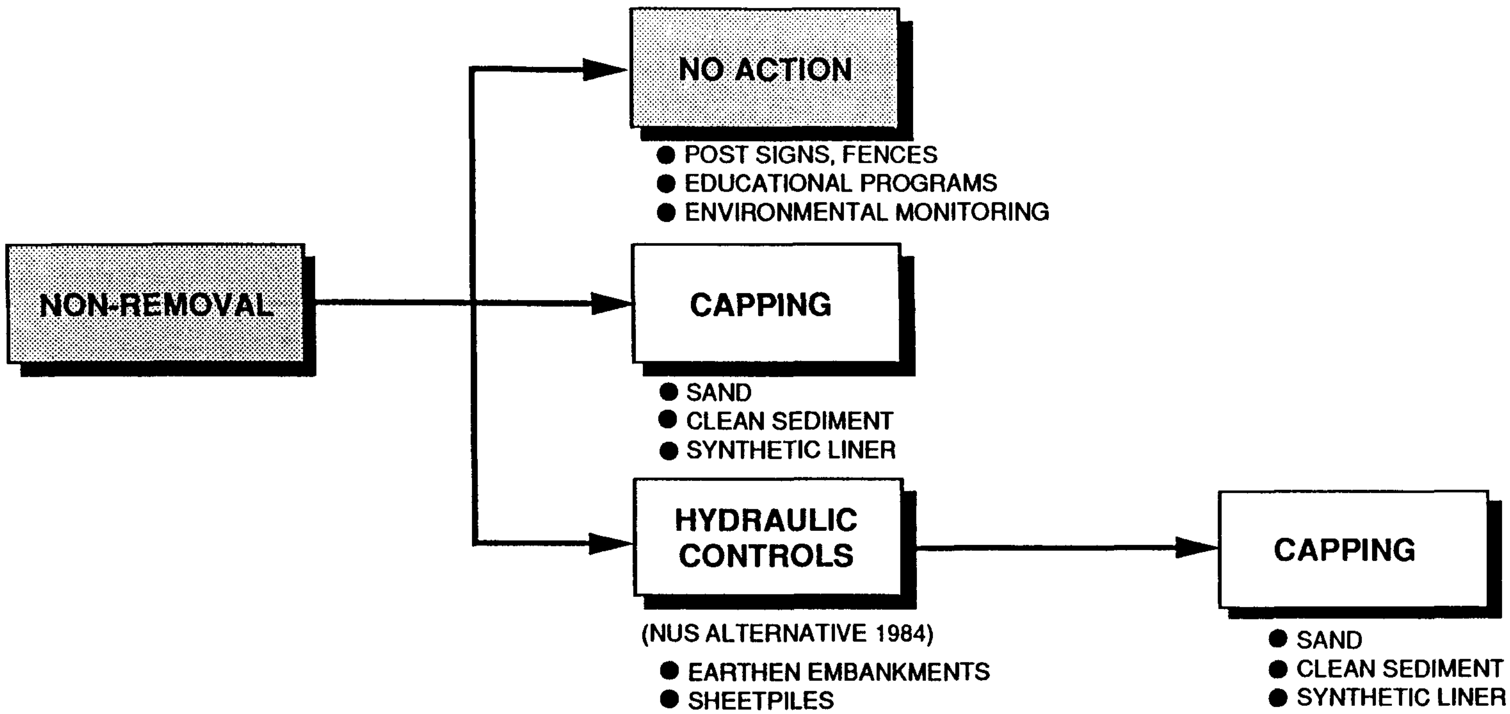


FIGURE 7-1
EST-1 AND LHB-1: NO ACTION
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

- site reviews conducted every five years

- continuation of public awareness programs

Warning signs in both English and Portuguese are currently in place along the western and eastern shorelines of the upper estuary. These signs warn the public that swimming and harvesting of shellfish and finfish are prohibited in this area. Additional warning signs would be placed at appropriate intervals along the shoreline of the estuary and the lower harbor/bay.

Public access to the estuary from land is limited because much of the land abutting the water is private property owned by commercial/industrial enterprises. To further restrict public access, a 6-foot-high chainlink fence with three-strand barbed wire would be installed along those areas of the estuary that are currently easily accessed. However, the fence would not restrict access from the water. Fencing of the lower harbor would be more of a problem. The shoreline on both sides of the harbor is extensively used by the commercial fishing fleet and for recreational boating. Numerous access points are available to the general public (e.g., boat launching ramps and a small park on Popes Island).

Institutional controls would be used to limit the potential for exposure by humans to site contaminants by restricting future site use. Currently, there is a ban on consumption of shellfish and finfish from the estuary and lower harbor/bay. This ban would remain in effect until the hazards associated with ingestion of contaminated seafood from the estuarine/harbor system have been reduced to a satisfactory level. Environmental monitoring would be conducted on a periodic basis until this level would be met.

Management for future use of the harbor would be required to reduce the potential of direct contact hazards, and minimize resuspension and migration of contaminated sediments during harbor maintenance activities. This would involve proper planning and management of future dredging activities and recreational uses. Dredging activities that could resuspend contaminated sediments would also have to be assessed for potential environmental risks associated with redistribution of contaminants. Currently, maintenance dredging is not allowed in the harbor due to the environmental and public health impacts. These institutional controls would be imposed by federal, state, and municipal governments. The actual means of implementation and duration of restrictions would be decided by the regulatory agencies at that time.

A long-term environmental monitoring program would be implemented to assess sediment contaminant levels and migration over time. Approximately 25 sediment and 25 water column samples would be collected four times per year and analyzed for PCBs and metals in both the estuary and lower harbor/bay. In addition, a biota monitoring program would be implemented to assess impacts to biota indigenous to the New Bedford Harbor system. Mussels or other natural biological integrators would be deployed and analyzed quarterly.

Because the data collected and model results have indicated that no significant reduction in PCB mass is taking place for the no-action alternative and is not expected to change within the 30-year study period, CERCLA legislation requires that the site be reviewed every five years. Data collected as part of the environmental program would be evaluated during the five-year reviews. Recommendations for potential remedial actions would be formulated at that time.

Public awareness programs would be implemented to educate the public on the potential health hazards associated with the estuary and lower harbor/bay area sediment. The programs would include periodic meetings and presentations in local neighborhoods, and bilingual pamphlets. These programs would be coordinated through the New Bedford Health Education Office, which opened in October 1985 to address PCB contamination in New Bedford Harbor and its potential impact on public health.

No active remediation of the wetland areas of the estuary would occur if this alternative were implemented. Because wetlands would not be disturbed, no adverse impacts to the wetlands would be imposed by this alternative. Wetlands studies conducted by Sanford Ecological Services, Inc. (1987) and IEP, Inc. (1988) have indicated that, although high concentrations of PCBs are present in the wetland and are bioaccumulated in the wetland organisms, the wetland areas continue to function as productive systems with high resource values (Bellmer, 1989).

7.2.2 Short-term Effectiveness

Because the no-action alternative involves only minimal site activities (i.e., installation of warning signs and fences, and environmental monitoring), it is not expected that these activities would pose a threat to those persons installing signs and fences or to the local community. However, a health and safety plan would be implemented for workers conducting the environmental monitoring. This plan would contain details for sampling and handling of contaminated sediment, including the level of protective clothing to be worn by the sign and fence installers.

7.2.3 Long-term Effectiveness and Permanence

The no-action alternative would not provide an effective or permanent long-term remedy for the estuary or the lower harbor/bay. Results of numerous transport studies (see Subsection 2.3) confirm a continuing net seaward flux of PCBs from the estuary into the lower harbor and out into Buzzards Bay. Study estimates of the PCB flux leaving the estuary range from 500 to 6,000 kg/yr (Thibodeaux, 1989; ASA, 1989; Teeter, 1988; and EPA, 1983b).

Ten-year projections of the no-action alternative using the TEMPEST/FLESCOT model indicate that the continued seaward flux of PCBs would decrease PCB mass in the top 4 cm of sediment by approximately 26 percent in the upper estuary, 21 percent in the lower harbor, and 60 percent in the outer harbor. However, a significant mass of PCBs would remain, particularly in the upper estuary, thereby serving as a continual source of contamination for the harbor system. The average bed sediment PCB concentrations in the upper estuary would remain high and relatively constant over the 10-year period ranging from 390 ppm at Year Zero to 273 ppm at Year 10 (Battelle, 1990).

Average water column PCB concentrations, associated with the bed sediment PCB concentrations, would decrease by approximately 50 percent in the upper estuary, 38 percent in the lower harbor, and 60 percent in the outer harbor. However, as shown in Figure 7-2, water column PCB concentrations at Year 10 in the estuary (1,107 ng/L) and the lower harbor (104 ng/L) would remain well above the AWQC of 30 ng/L.

Results of the TEMPEST/FLESCOT projections reflect bed sediment PCB mass confined to the upper 4 cm (1.6 inch) surficial layer only. Sediment PCB mass in the harbor is actually much greater and extends below the 4-cm model boundary; the majority of the PCB mass resides in the upper 30 cm (12 inches) of sediment in the estuary, and the upper 15 cm of sediment in the lower harbor. Although the availability of this mass of PCBs to the overlying water column depends on numerous factors or processes (e.g., vertical diffusion, bioturbation, bed sediment erosion, or scouring), it is unreasonable to assume that over time this sediment PCB mass would remain completely isolated from the water column. USACE concluded that a 55-cm cap would be required to isolate the contaminated sediment from the overlying water column. Therefore, results of the TEMPEST/FLESCOT model may considerably underestimate the actual PCB sediment and water column concentrations over the 10-year period of simulation.

A 10-year projection of PCB concentrations in biota under the no-action alternative was examined using the WASTOX food chain model (Battelle, 1990). The edible-to-whole-body PCB ratio of 0.18 in flounder translates the FDA action limit of 2 ppm to 11

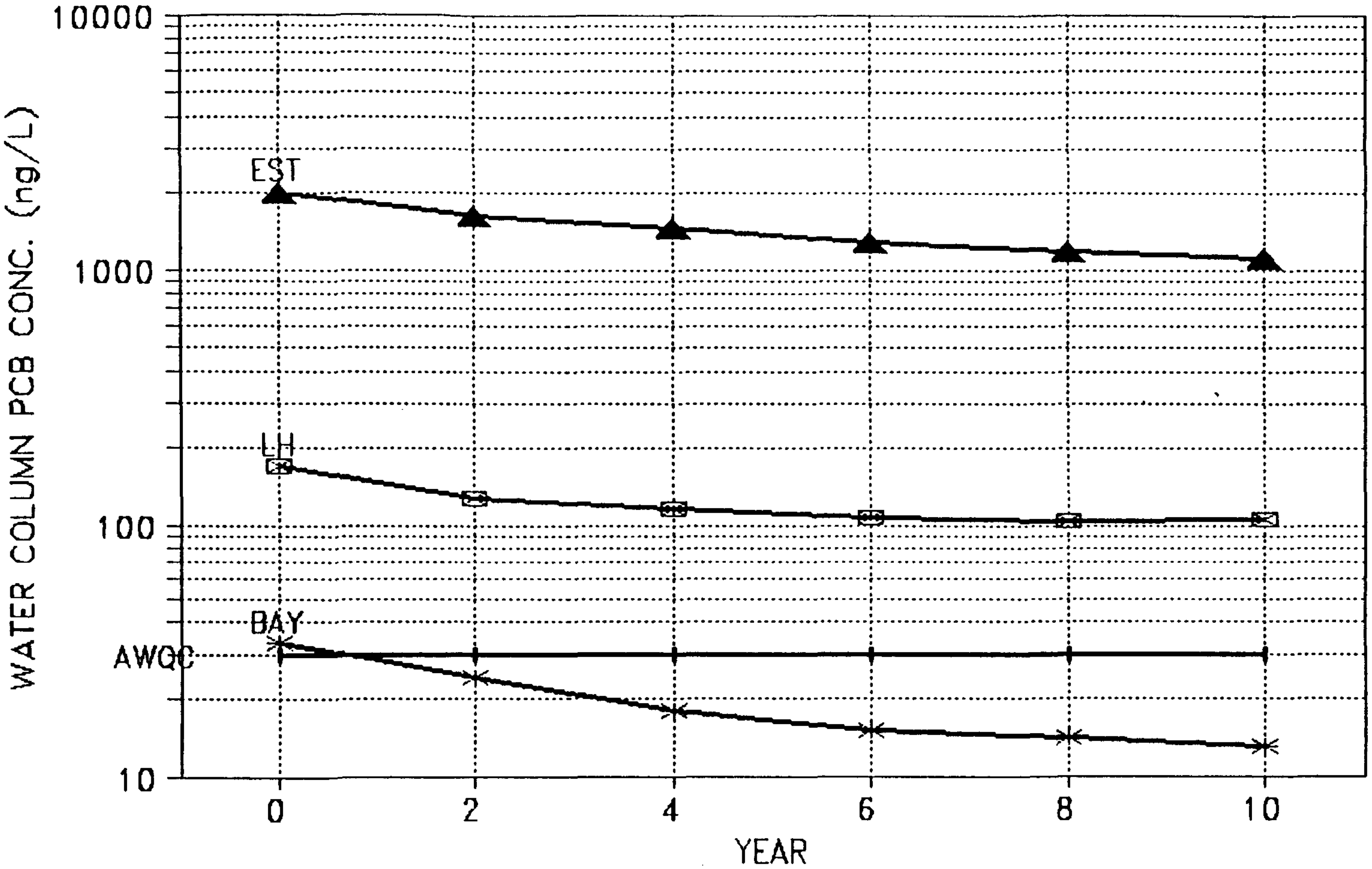


FIGURE 7-2
WATER COLUMN PCB CONCENTRATIONS FOR THE NO ACTION ALTERNATIVE
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

ppm whole body (Battelle, 1990). Results of this projection indicate that whole-body PCB concentrations in flounder inhabiting the lower harbor area remain relatively constant for all age classes over the 10-year period. Flounder PCB concentrations in Age Class 1 (Zero to 1 year old) range from 6.6 ug/g at Year Zero to 5.4 ug/g at Year 10; flounder PCB concentrations in Age Class 6 (5 to 6 years old) range from 8.6 ug/g at Year Zero to 8.3 ug/g at Year 10. Therefore, older flounder in the lower harbor area are projected to remain close to the action limit.

No projection was made for lobster because only one lobster was caught in the lower harbor, resulting in insufficient data for a model calibration run in this area.

A drop in PCB concentration was projected to occur in both the flounder and the lobster inhabiting the outer harbor area. Flounder in all age classes were well below the FDA action limit at the start of the 10-year projections: 2.17 and 3.36 ug/g for Age Classes 1 and 6, respectively, at Year Zero. At Year 10, flounder PCB concentrations had declined to 0.89 and 1.44 ug/g for Age Classes 1 and 6, respectively.

The whole-body equivalent of the FDA action limit for lobster is 0.22 ppm (Battelle, 1990). The edible tissue level for lobster is lower than the whole-body level because the tomalley (i.e., the hepatopancreas) is considered edible. At the start of the 10- year WASTOX projection, lobster PCB concentrations were approximately 2.5 times the FDA action limit: 0.54 and 0.55 ug/g for Age Classes 1 and 6, respectively. However, at the end of 10 years, PCB concentrations in lobster were essentially at the action limit: 0.22 and 0.23 ug/g for Age Classes 1 and 6, respectively. The variation in concentration with age class is much less for the lobster than for the flounder, reflecting differences in bioenergetics between the species.

Results of the WASTOX model are based in part on a set of assumptions and initial conditions established as part of the overall Battelle-HydroQual modeling program for New Bedford Harbor (Battelle, 1990). The results of biota monitoring conducted over the last decade show that PCB concentrations in lobster and flounder have remained relatively constant, exceeding the 2-ppm FDA action limit (Kolek and Ceurvels, 1981; and Pruell et al., 1988).

Although model projections suggest a general decline in biota PCB concentrations to levels at or below the FDA action limit, biota populations themselves may be adversely impacted at contaminant levels that would not result in tissue levels in excess of the FDA action limit. To project potential future risk to biota under the no-action scenario, the methodology developed for the baseline ecological risk assessment was applied to results of the TEMPEST/FLESCOT model. The MATC to marine fish, crustaceans, mollusks, and alga was used as the benchmark. The MATC represents the threshold for significant effects on growth, reproduction, or survival and is based on the most sensitive response of the organism to the contaminant in question. A more thorough discussion of how the MATCs were developed and applied is presented elsewhere (E.C. Jordan Co./Ebasco, 1990).

Based on an average water column PCB concentration of 1,107 ng/L in the upper estuary at the end of the 10-year model simulation, the MATC for 80 percent of the marine fish would be exceeded. That is, there would be an 80 percent probability at the end of 10 years that a marine fish residing in the estuary would be adversely impacted in terms of growth, reproduction, or survival. Because of their much greater sensitivity to dissolved PCBs, marine fish are the most heavily impacted group. Crustaceans, mollusks, and algae would have a smaller yet still serious impact from exposure to PCB concentrations in the upper estuary; this is due to wider ranges of sensitivities to PCB exposure. Nonetheless, the MATCs for 35 percent of the crustaceans, 20 percent of the mollusks, and 35 percent of the algae would be exceeded.

The risk to biota due to contaminated sediment results from the direct exposure to the sediment and its associated pore water, and not to overlying water contaminated from the sediment. Exposure of benthic species to contaminated sediment was evaluated in the baseline ecological risk assessment by calculating pore water PCB concentrations from associated sediment PCB concentrations using mass transfer coefficients developed for the TEMPEST/FLESCOT model (E.C. Jordan Co./Ebasco, 1990). This approach results in pore water concentrations that are generally higher than the overlying water column concentrations.

Based on an average sediment PCB concentration of 273 ppm in the upper estuary at the end of the 10-year model simulation, the MATCs for 95 percent of the marine fish, 65 percent of the crustaceans, and 60 percent of the mollusks would be exceeded. The evaluation was not conducted for algae because they would not be expected to be exposed to sediment pore water. Furthermore, there is considerable variability in behavior and habitat preference among the species comprising all three taxonomic groups, and some species (e.g., pelagic fish, mussels, and copepods) would not be expected to have any direct contact with sediment pore water (E.C. Jordan Co./Ebasco, 1990).

The reduced water column PCB concentrations in the lower harbor at the end of the 10-year model simulation would have a smaller yet still serious impact. Based on an average water column PCB concentration of 104 ng/L, the MATCs for 40 percent of the marine fish, 10 percent of the crustaceans, 10 percent of the mollusks, and 20 percent of the algae would be exceeded.

The average sediment PCB concentration in the lower harbor at the end of the 10-year model simulation was 8 ppm. Based on the associated pore water PCB concentration, the MATCs for 10 percent of the marine fish, 15 percent of the crustaceans, and 15 percent of the mollusks would be exceeded. An initial sediment PCB concentration of 10 ppm was established as the average sediment bed concentration over the entire lower harbor area. In reality, there are localized areas of more highly contaminated sediments. Therefore, the risks to biota presented herein may be underestimated for the lower harbor area.

Public health risks in excess of MCP requirements and EPA target risk ranges were estimated based on exposure to current shoreline PCB concentrations. The shoreline sediments in the estuary contain PCB concentrations ranging from an average of approximately 150 ppm (lower estuary) to 380 ppm PCB (upper estuary). A TCL of 10 ppm PCB was established for the shoreline sediments based on the protection of public health. The reduction in PCB concentrations under the no-action alternative is not considered significant enough to provide an adequate level of protection to public health. More than an order-of-magnitude reduction in these concentrations would be required to bring associated risks from direct contact and incidental ingestion exposure to 10^{-5}.

The baseline risks from direct contact and incidental exposure to shoreline sediments were less in the lower harbor/bay than in the estuary. The average sediment PCB concentration after 10 years is 8 ppm. However, PCB concentrations in shoreline sediment were detected in excess of the 10-ppm TCL. These concentrations may not decrease to the 10-ppm level under a no-action alternative until 10 years.

Long-term monitoring of bed sediment, water column, and biota, and continued maintenance of institutional controls, would be required for the no-action alternative. Five-year site reviews of existing conditions would also be conducted to assess the need for remedial action.

7.2.4 Reduction in Mobility, Toxicity, and Volume

Because no sediment treatment processes are used, this alternative would not result in any significant reduction in the mobility, toxicity, or volume of contaminants in the sediment.

7.2.5 Implementation

7.2.5.1 Technical Feasibility

Installing fencing and posting warning signs are simple construction tasks. Local contractors and necessary materials are readily available. Restricting access to the estuary and the lower harbor/bay would not interfere with the ability to perform future remedial action. Maintenance and repair of the fence and warning signs, and an environmental monitoring program, are tasks that are easily implemented.

7.2.5.2 Administrative Feasibility

Long-term institutional controls would be difficult to effectively administer for the no-action alternative in the estuary because of the size of the study area. For example, although fishing and clamming is currently banned from this area, these activities have been identified almost every time a trip was made to the area. Comprehensive reviews would be necessary every five years.

Administrative feasibility would also be difficult in the lower harbor/bay because the dredging ban currently in effect would remain so for minimal no-action. This would severely limit future development of the harbor and, with time, may limit access currently available because of sediment deposition in the channel area.

7.2.5.3 Availability of Services and Materials

Fencing, signs, and security services are locally available in the New Bedford area. Personnel and equipment are also available to carry out the monitoring program.

7.2.6 Cost

The total 30-year present-worth cost of the no-action alternative for the estuary is estimated at $4.1 million, which includes an initial capital cost of $280,000 for fencing (Table 7-1). Annual operating costs are the predominant costs for these alternatives, and include annual fence maintenance, site inspection, public information programs, and environmental monitoring.

The 30-year present-worth cost for the lower harbor/bay is estimated at $3.4 million (Table 7-2). Because no fencing will be installed in the lower harbor/bay because of the commercial nature of the harbor, direct costs are limited to institutional controls (i.e., warning signs and public information programs). The greatest portion of the total cost for this alternative is attributed to the monitoring program.

TABLE 7-1
COST ESTIMATE: ALTERNATIVE EST-1
NO ACTION
NEW BEDFORD HARBOR

ACTIVITY	COST
I. DIRECT COST	
A. Fencing	$280,000
DIRECT COSTS	$280,000
II. INDIRECT COST	
A. Health and Safety (@ 5%) Level D Protection [Activity: A]	$14,000
B. Legal, Administration, Permitting (@ 6%)	$17,000
C. Engineering (@ 10%)	$28,000
D. Services During Construction (@ 10%)	$28,000
E. Turnkey Contractor Fee (@ 15%)	$42,000
INDIRECT COSTS	$129,000
SUBTOTAL COSTS	$409,000
CONTINGENCY (@ 20%)	$82,000
TOTAL CAPITAL COSTS	$491,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000
OPERATION AND MAINTENANCE COSTS	
Fence Maintenance	$215,000
Site Inspections	$5,000
Institutional Controls	$5,000
TOTAL O&M COSTS (present worth @ 5% for 30 years)	$225,000
TOTAL COST - ALTERNATIVE EST-1	$4,092,000

TABLE 7-2
COST ESTIMATE: ALTERNATIVE LHB-1
NO ACTION
NEW BEDFORD HARBOR

ACTIVITY	COST
MONITORING PROGRAM	$3,376,000
(present worth @ 5% for 30 years)	
OPERATION AND MAINTENANCE COSTS	
Site Inspections	$5,000
Institutional Controls	$5,000
TOTAL O&M COSTS	$10,000
(present worth @ 5% for 30 years)	
TOTAL COST – ALTERNATIVE LHB-1	$3,386,000

Environmental monitoring includes sampling and analysis costs for 25 sediment, 25 water column, and 25 biota samples collected quarterly. Also included are costs for interpretation of results and five-year reviews at $99,000 per area. The monitoring program for each area is estimated to cost approximately $6.5 million ($3.4 million present worth). Five-year review costs are associated with data interpretation, reassessment of risks, and public meetings. Figures 7-3 and 7-4 illustrate a cost breakdown of the no-action alternative for the estuary and lower harbor/bay, respectively.

7.2.7 Compliance with ARARs

Under the no-action Alternatives EST-1 and LHB-1, commercial and recreational boat traffic would be limited to south of the Coggeshall Street Bridge because of fences and institutional controls. These activities attempt to restrict access to the contaminated areas to minimize public health risks. Although the estuary is too shallow to accommodate commercial vessels, access could still be obtained via smaller recreational boats. The chemical-specific ARARs for this alternative are regulations that protect the surface water and seafood. Surface water regulations include Massachusetts Surface Water Quality Standards (310 CMR 4.00) and federal AWQC. The FFDCA established a 2-ppm PCB level in commercial seafood, which needs to be considered for the estuary and the lower harbor/bay (see Table 4-1). This alternative would not comply with the surface water ARARs because the sediment would remain untreated within the estuary and the lower harbor/bay, and is still available for uptake by human and aquatic organism receptors. Based on the TEMPEST-FLESCOT projections for the no-action alternative, PCB concentrations in the water column of the estuary and the lower harbor would not reach water quality standards of 30 ng/L within 10 years. PCB concentrations in the outer harbor are projected to decrease from just above regulatory levels (33 ng/L) in Year Zero to less than 30 ng/L in Year 10.

The no-action alternative will not comply with the MCP requirement that the total site risk not exceed $1x10^{-5}$.

Because there would be no activity in the wetlands or floodplains of the Acushnet River Estuary, the location-specific ARARs identified in Section 4.0 are not appropriate for the estuary no-action alternative.

Potential action-specific ARARs associated with this alternative pertain to the OSHA worker protection standards, and Massachusetts Right-to-Know Laws. OSHA promulgated regulations to protect workers by establishing (1) standards for airborne levels of PCBs that are protective of public health; (2) required protective equipment, clothing, and procedures for on-site workers; and (3) recordkeeping and reporting requirements of employers.

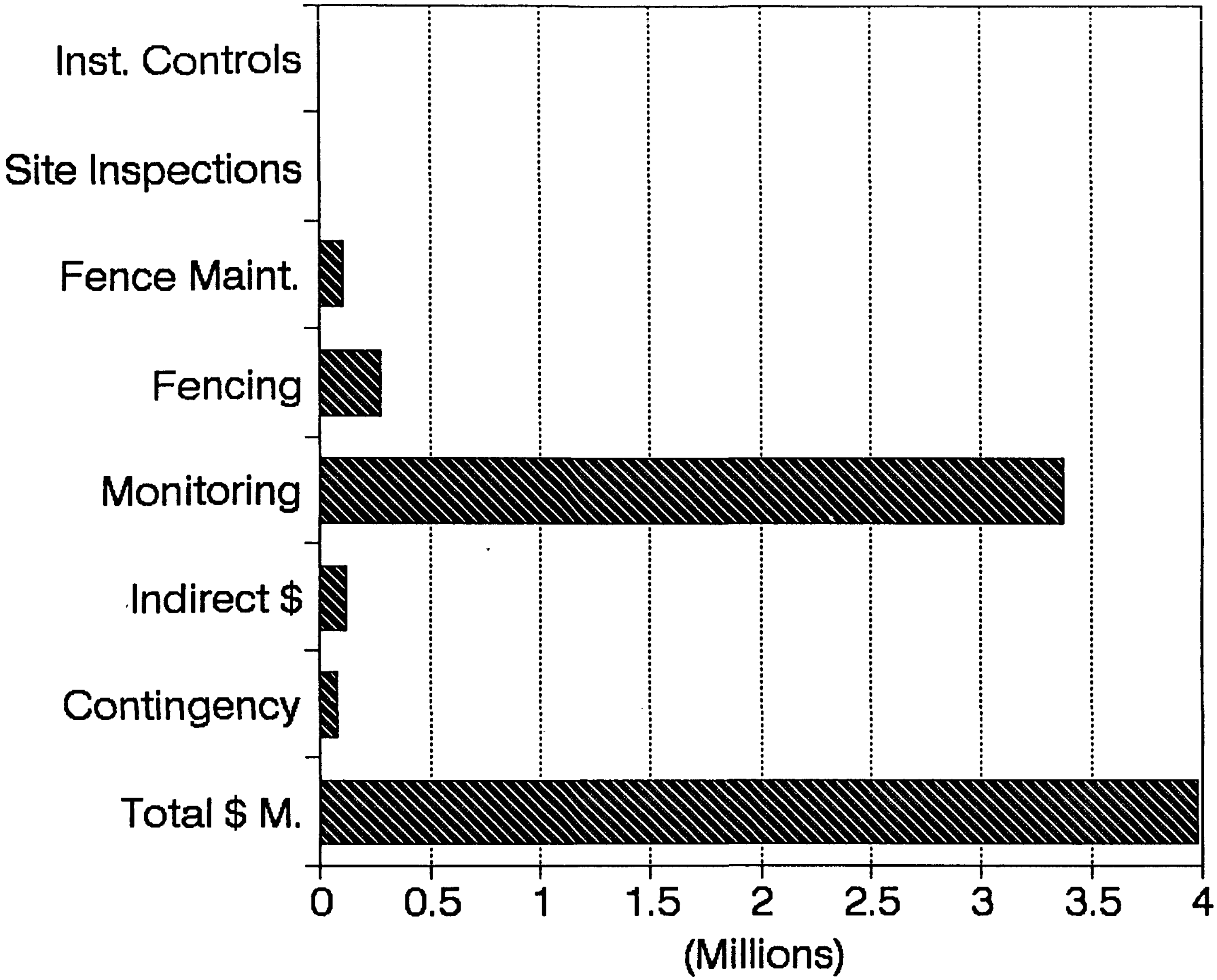


Figure 7-3

Cost Breakdown EST-1
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

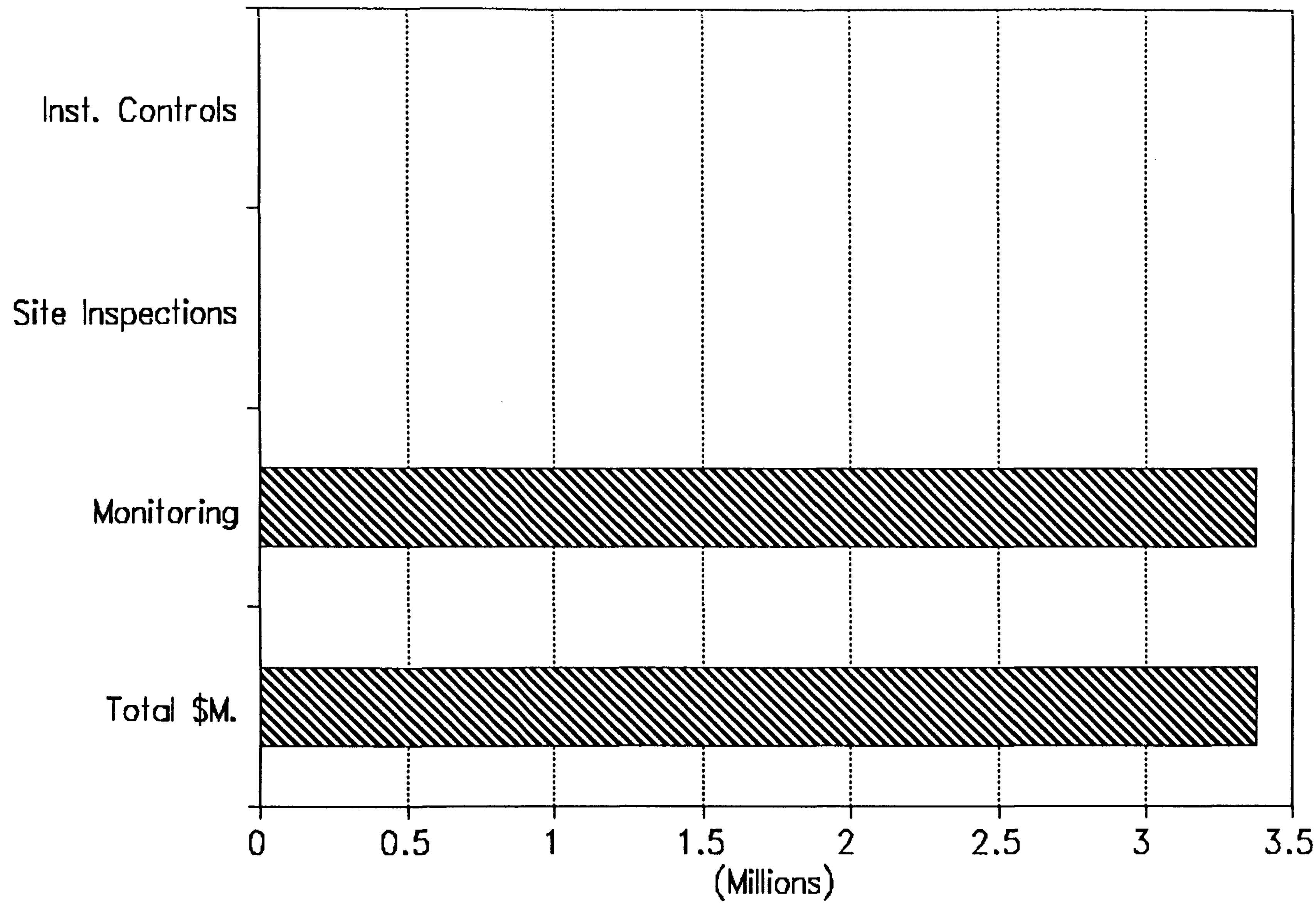


Figure 7-4

Cost Breakdown LHB-1
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

Massachusetts provides for the protection of employees and communities through the following three separate Right-to-Know regulations:

- o Department of Public Works: Hazardous Substance Right-to-Know (105 CMR 67)
- o DOI: Hazardous Substance Right-to-Know (441 CMR 21)
- o MADEP: Hazardous Substance Right-to-Know (310 CMR 33)

Both OSHA and Right-to-Know regulations are applicable to the installation of the fence and will be complied with during remedial action.

Appendix A outlines potential chemical- and action-specific ARARs for this alternative and specifies the corresponding remedial actions that would be required to attain the specific ARARs, if the ARAR can be attained.

7.2.8 No-Action Overall Protection of Public Health and the Environment

The no-action alternative will not provide an adequate level of protection of either public health or the environment. There would be minimal, if any, reduction in risk over baseline conditions. Institutional controls, such as fencing and posting warning signs, would not completely eliminate human exposure to sediments. In addition, because no action is taken to reduce the mobility or volume of PCB-contaminated sediments, this medium will continue to act as a source of surface water and biota contamination. Levels of PCBs in surface water from the estuary to the inner harbor will remain above the AWQC and PCB concentrations in biota are expected to remain in excess of the FDA tolerance level. Direct exposure by aquatic receptors to surface water and sediments is associated with adverse ecological impacts.

7.3 ALTERNATIVES EST-2 AND LHB-2: CAPPING

7.3.1 General Description

Alternatives EST-2 and LHB-2 are the nonremoval containment alternatives that were retained for detailed analysis (Figure 7-5). Remediation is based on the assumption that placing a cap over the contaminated sediment would effectively isolate and contain the PCBs and heavy metals present.

Consistent with the other alternatives discussed herein, this alternative is designed to address contamination of sediments in excess of 10 ppm PCBs. Approximately 187 acres in the estuary

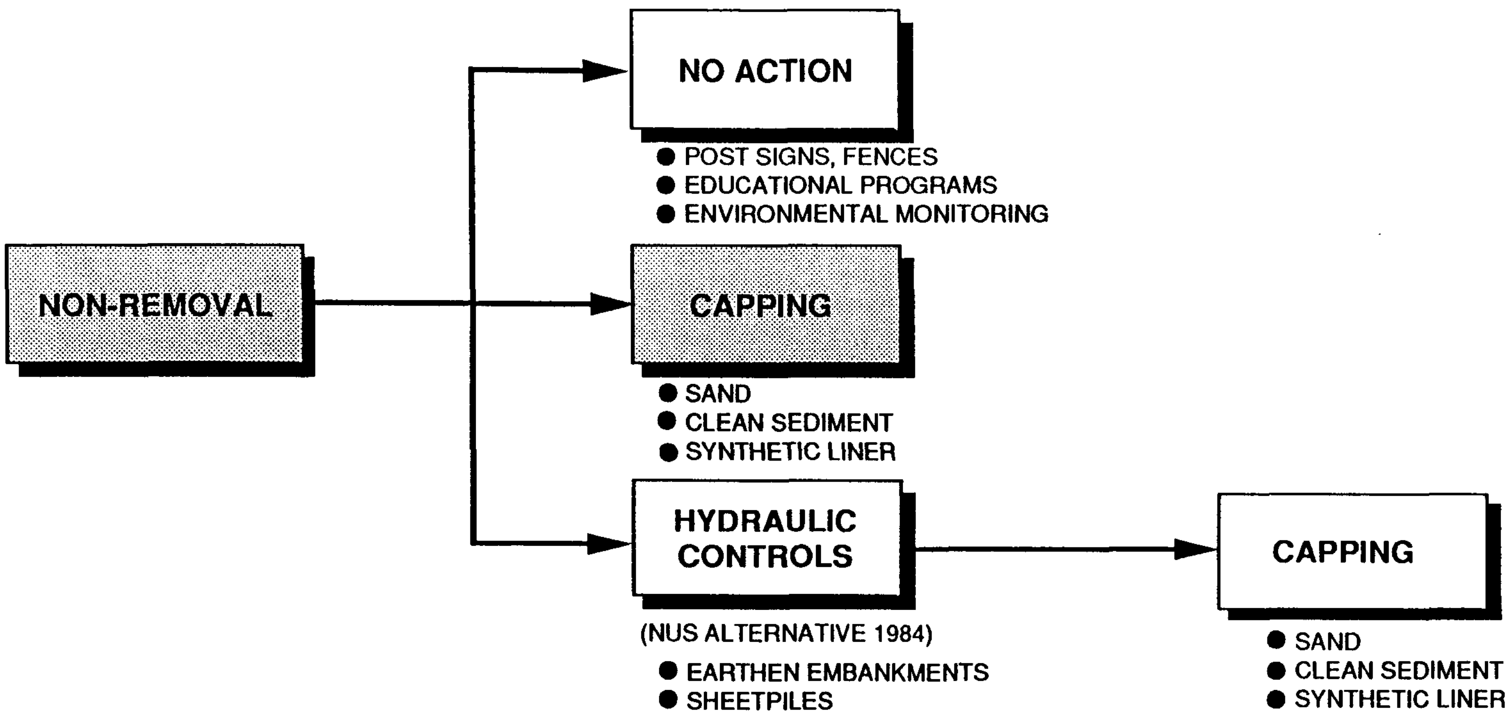


FIGURE 7-5
EST-2 AND LHB-2: NO ACTION
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

and 171 acres in the lower harbor/bay would require capping to achieve this TCL.

The following subsections describe how this alternative would be implemented in the estuary. Construction of caps in the lower harbor/bay area would be somewhat different because the bathymetry is different, the water column is significantly deeper, and the sediments consist of more sands and, therefore, may be more likely to support capping material without the additional support of geotextile. Capping in the lower harbor/bay is discussed following the estuary discussion.

7.3.1.1 Estuary Capping

Because of the soft sediments present in the estuary, USACE recommended that the capping material be hydraulically placed (as opposed to trying to work in dry conditions from the shore). Because a portion of the estuary becomes a mudflat at low tide and other areas are very shallow, hydraulic controls are necessary to maintain sufficient water depth throughout the tidal cycle for the barge(s) and work boats to move in the estuary.

The initial step in this remedial alternative is to construct a dam with adjustable height weirs at the Coggeshall Street Bridge. The purpose of this dam would be to allow control of tidal flow, reduce hydraulic dynamics to allow easier placement of capping material, and reduce release of contaminated sediments during construction. The dam would be tied in to both the Fairhaven and New Bedford shorelines just north of the bridge proper and would probably be constructed of sheetpiling. A weir structure using adjustable panels that could be raised and lowered with winches would control the flow of water through the dam. Upstream hydraulic controls may also be implemented to aid in the control of stormwater discharge during such an event. These additional controls may be placed at the Saw Mill Dam or the New Bedford Reservoir Dam.

Once the hydraulic controls are in place, geotextile would be laid down on top of the contaminated sediment to prevent intermixing of the contaminated sediments with the clean capping material during placement. The geotextile should also significantly limit the resuspension of contaminated sediments during cap installation and will encourage uniform settlement after cap placement.

The geotextile could be deployed either by anchoring it at one end and pulling the material across the estuary with cables and winches from a barge, or by unrolling the fabric from barges. The proposed method of placement involves unrolling a 150-by-400-foot section of the geotextile using a crane barge with winches and a shallow draft tug boat (i.e., approximately

32 feet long by 12 feet wide with a 3.5- to 4.5-foot draft), which can be transported over land. The western shoreline would be improved with a gravel access road and the geotextile would be anchored and unrolled perpendicular to the shoreline. Placement of fabric along the center and eastern side of the estuary will be conducted from the barge (USACE-NED, 1990). The geotextile, having a specific gravity similar to water, will have to be submerged once deployed. (This feature also enhances positioning of the material.) Sand bags, iron rods, or a thin layer of the capping material may be used to sink the geotextile. This sequence would continue until the appropriate areas were covered. Sufficient overlap would be maintained between sheets (i.e., 10 to 15 feet) to prevent migration of the contaminated sediment during placement of the cap material. Figure 7-6 depicts conceptual geotextile deployment operations.

Once the geotextile is in place, the capping material can be laid down. The capping material should consist of sand with minimal amounts of fines and stone. A minimum cap thickness of 55 cm would be required to provide an effective chemical and biological barrier (Shafer, 1988).

Because adherence to the minimum 55-cm specification with no excess would be technically impractical in terms of a contractor's ability to accurately place the material, USACE recommends that the contractor be allowed to place an additional 30 cm (i.e., 1 foot) of capping material to ensure that the minimum 55-cm cap is attained. Therefore, the total cap thickness recommended is 85 cm (approximately 3 feet).

To cover the 187 acres with 3 feet of sand, 818,000 cy of material will be required. Because it would not be environmentally feasible nor administratively probable to obtain this amount of material offshore, it would have to be obtained from land-based borrow pits, preferably in the harbor vicinity. Material similar to that specified for capping was used to construct the USACE pilot study CDF. The material used in this project was the rock-cutting waste obtained from the Tilcon Quarry located in Acushnet, approximately 5 miles away. An additional borrow pit has also been located within 15 miles of the estuary.

The material would be trucked to temporary slurry ponds constructed along the shoreline at accessible locations. The slurry ponds may be made by installing sheetpile walls along the shoreline and excavating a pit on the shoreline side of the wall large enough to allow a small dredge to operate within it. The dredge would be used to pump the slurried sand to the depositional locations by means of floating pipeline. Figure 7-7 depicts this operation. Because of the distance required to pump the slurry, booster pumps may be required.

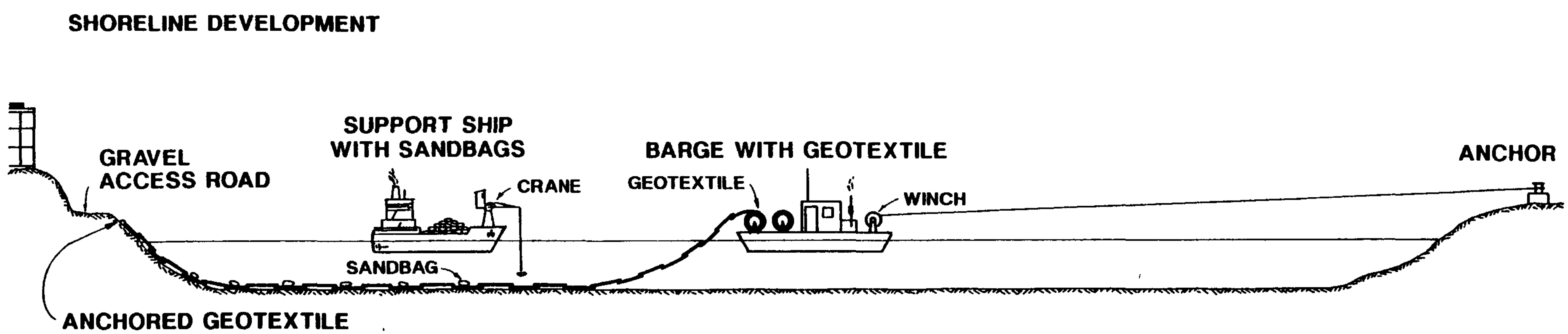


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FIGURE 7-6
PLACEMENT OF GEOTEXTILE FOR CAPPING
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

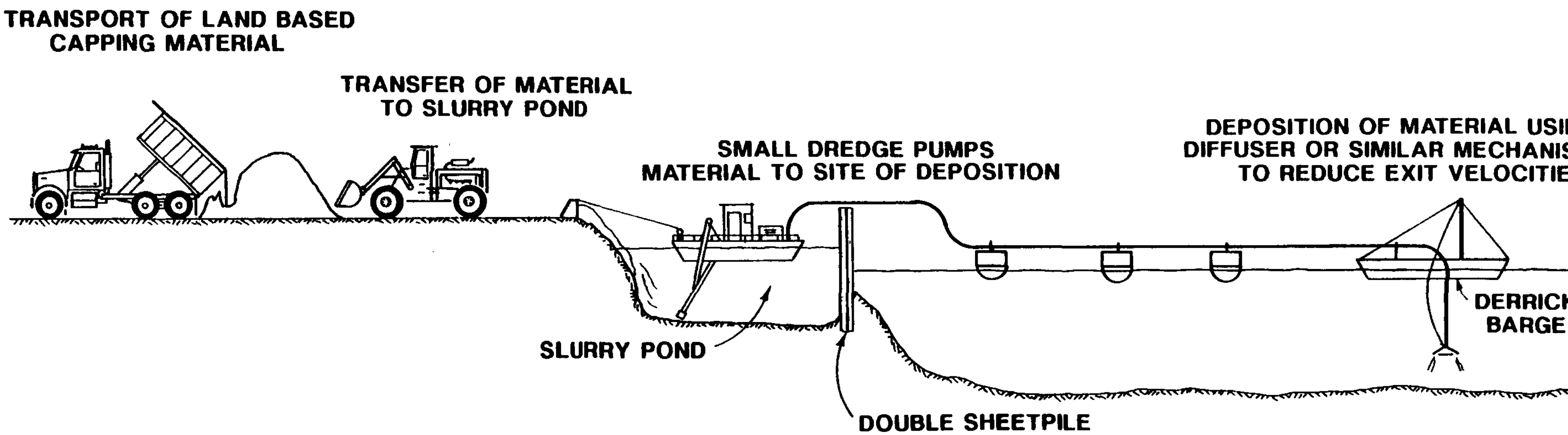

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FIGURE 7-7
PLACEMENT OF CAPPING MATERIAL
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

The slurry would be discharged onto the geotextile until the minimum thickness of 55 cm was attained. A diffuser or other discharging system would be used to dissipate exit velocities of the capping slurry. It is likely that the contractor would exceed this specification by up to a foot, because returning to "top off" areas not sufficiently covered would be more costly. The cap would be tapered at its boundaries to prevent unnecessary erosion and scour from surface runoff along the shoreline.

In areas of high flow velocities, additional armoring would be necessary to prevent erosion of the cap, which may be constructed in the following manner (Balsam, 1989). To prevent mixing and damage to the newly laid cap, a geoweb would be placed in those areas to be armored. Stone protection in the form of 2- to 6-inch-diameter rocks would be placed over the geoweb using a crawler-type crane mounted on a barge or working from the shoreline.

To ensure that a minimum 55-cm cap is placed in the estuary, an extensive, continuous monitoring program would be required during construction. The monitoring program would consist of sediment coring, installation and monitoring of settlement plates, and hydrographic surveying.

Because the estuarine bathymetry would be altered by approximately 3 feet, the combined sewer overflows (CSOs) and other discharge lines would have to be diverted or plugged. In the case of the CSOs, the City of New Bedford is in the process of upgrading its entire sewer system under the guidance of the engineering firm Camp, Dresser & McKee, Inc. Therefore, these CSOs can most likely be plugged and/or rerouted to the main interceptor line. The remaining discharge pipes, most of which were placed without consent from the City of New Bedford (Boucher, 1987), will have to be plugged off so as not to detrimentally affect the cap integrity.

Like the no-action alternative, this alternative does not include provisions for wetland remediation. The estuary cap would not extend over vegetated wetland areas currently above +4 feet MLW. Cap placement would result in the creation of new intertidal area and the loss of some existing intertidal area. These areas could be planted with the appropriate wetland vegetation to create additional high marsh area. Due to the change in the estuary bathymetry resulting from cap placement, new tidal flats would be created, and the existing saltmarshes could be converted to uplands.

<u>7.3.1.2 Lower Harbor/Bay Capping</u>

Because of the shipping activity in the harbor, including the actual shipping channel, all areas within the harbor/bay requiring remediation cannot reasonably be capped. Therefore, only those areas that would not affect the harbor traffic are considered for capping. At 10 ppm, this includes areas around Marsh Island, one large area between Marsh and Popes islands, two smaller locations inside the Hurricane Barrier, and another two just beyond the Hurricane Barrier adjacent to the western shoreline. Together, these areas encompass approximately 171 acres (Figure 7-8).

The other locations within the harbor requiring remediation include areas along the western shore between the Coggeshall Street Bridge and the Route 6 Bridge, and another just south of Fish Island (also the Route 6 Bridge) along the western shore. These areas will require dredging so that the active harbor can continue to be utilized (and further developed, as needed). The dredged material would then be pumped to CDFs for disposal. Effluent from the dredge slurry would be treated in the secondary cell prior to discharge back to the harbor system. Subsection 7.4 describes the dredging alternative in detail.

The water depth in this area is sufficient to support larger dredging equipment; therefore, hydraulic controls beyond those afforded by the Hurricane Barrier (during storm events) would not be required, nor would they be readily implemented.

If geotextile is determined necessary to support the capping material, methods for placement would be similar to those described for the estuary. Installation of the geotextile would probably be conducted from barges to minimize interference with harbor traffic. For purposes of the cost estimate, it is assumed that geotextile would be used.

Given the water depth, an additional foot or two of capping material could be placed to ensure an adequate cap thickness even if some intermixing with contaminated sediments were to occur. Placement of the additional capping material could negate the need for a geotextile and would be significantly less expensive than laying the geotextile. USACE review of the sediment geotechnical properties would be necessary to determine the need for a geotextile.

The method of cap placement in the lower harbor/bay may also be somewhat different. The cap material from a land-based source would be slurried in a pond that would be in a location accessible by barge but not within the traffic flow of the shipchannel. The slurried material would be pumped onto barges, then transported to the deposition sites. From there, the material would be pumped from the barge and discharged through a diffuser onto the harbor bottom.

The capped areas would not be subjected to significant flow velocities. Therefore, additional armoring of the caps using

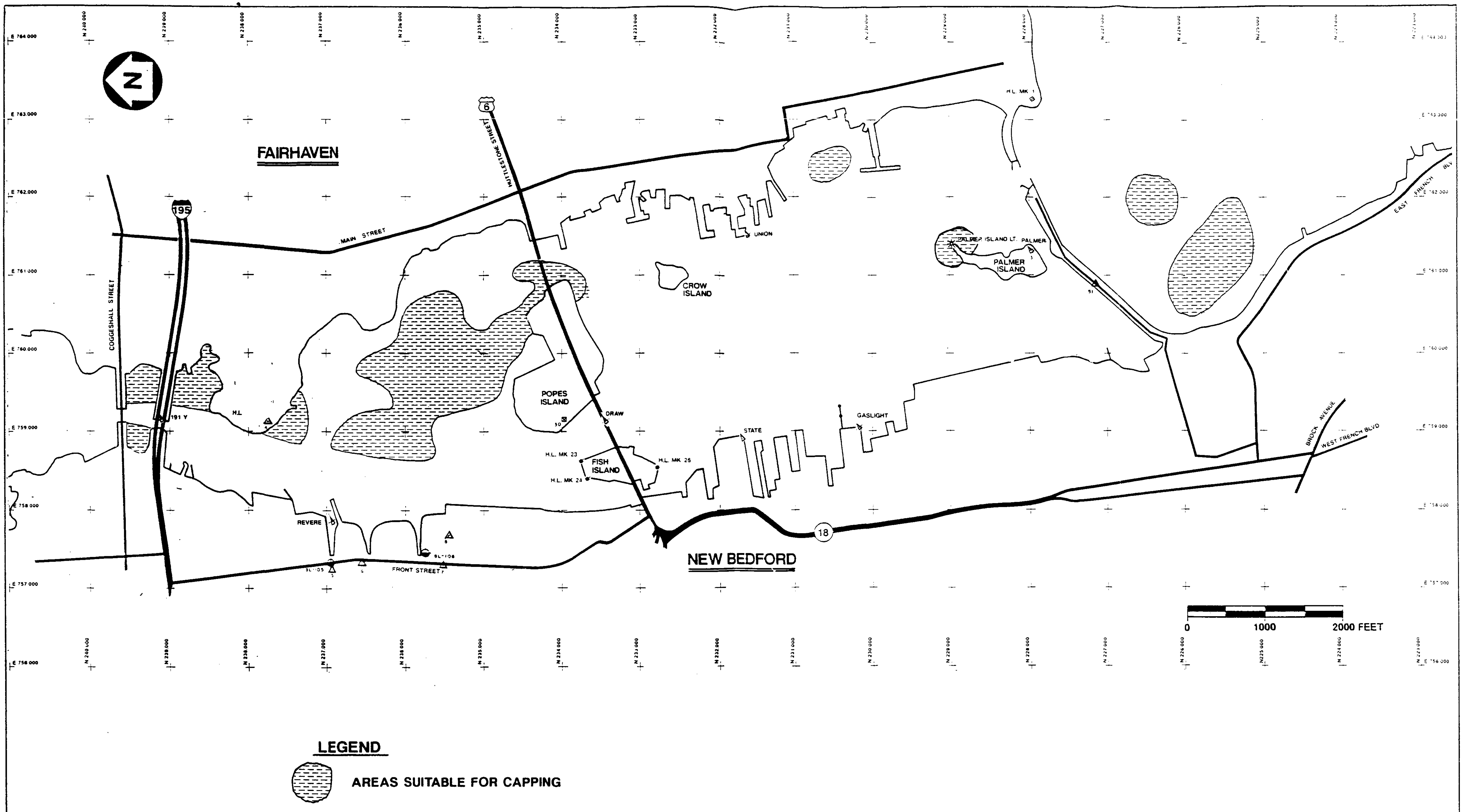

FIGURE 7-8
AREAS SUITABLE FOR CAPPING IN LOWER HARBOR AND BAY
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

rip-rap would not be necessary in those areas identified in the lower harbor/bay.

7.3.2 Short-term Effectiveness

Minimal risk to the community is anticipated for this remedial alternative. USACE predicts that a capping operation is anticipated to release less contamination than a dredging operation, although accurately quantifying the difference would be difficult (USACE-NED, 1990). The use of geotextile should minimize resuspension of sediments during placement of the sand capping material.

Risks to workers on-site during remediation are also anticipated to be low. The only opportunity for contact of contaminated sediment is during geotextile anchoring. Workers involved in anchoring activities would be protected with appropriate health and safety equipment and clothing.

7.3.3 Long-term Effectiveness and Permanence

USACE considers capping to be effective in terms of containing contaminants, assuming a cap of adequate thickness is placed and continuously maintained (USACE-NED, 1990). Studies conducted by USACE-WES concluded that a minimum thickness of 35 cm was required to provide a chemical seal (i.e., would not allow PCBs to migrate through) (Sturgis, 1988). Furthermore, a 20-cm bioturbation barrier was recommended to prevent benthic organisms from burrowing into the chemical barrier. This layer should also prevent root systems from acting as preferential pathways for contaminant migration.

Because hydraulic placement of the sand capping material is an inexact construction procedure and uniform placement of 55 cm is difficult to achieve, a 30-cm lift (i.e., 1 foot) above the minimum required thickness is considered a reasonable buffer to ensure that the minimum cap is obtained.

An extensive monitoring program is envisioned to ensure that the cap integrity is maintained. This program would include hydrographic surveys and sediment cores to provide this function. Institutional controls would probably still be required to prevent clamming, small boat traffic, or other activities from damaging the integrity of the cap.

Capping will have a significant impact on the estuary, with much of it being changed into intertidal area. Assuming a 34-inch cap was placed and settles 6 inches, approximately 97 acres of intertidal area would be created (Figure 7-9) (USACE-NED, 1990).

Because the sand cap would meet the existing shoreline between the low and high water lines, no upland areas would be created.

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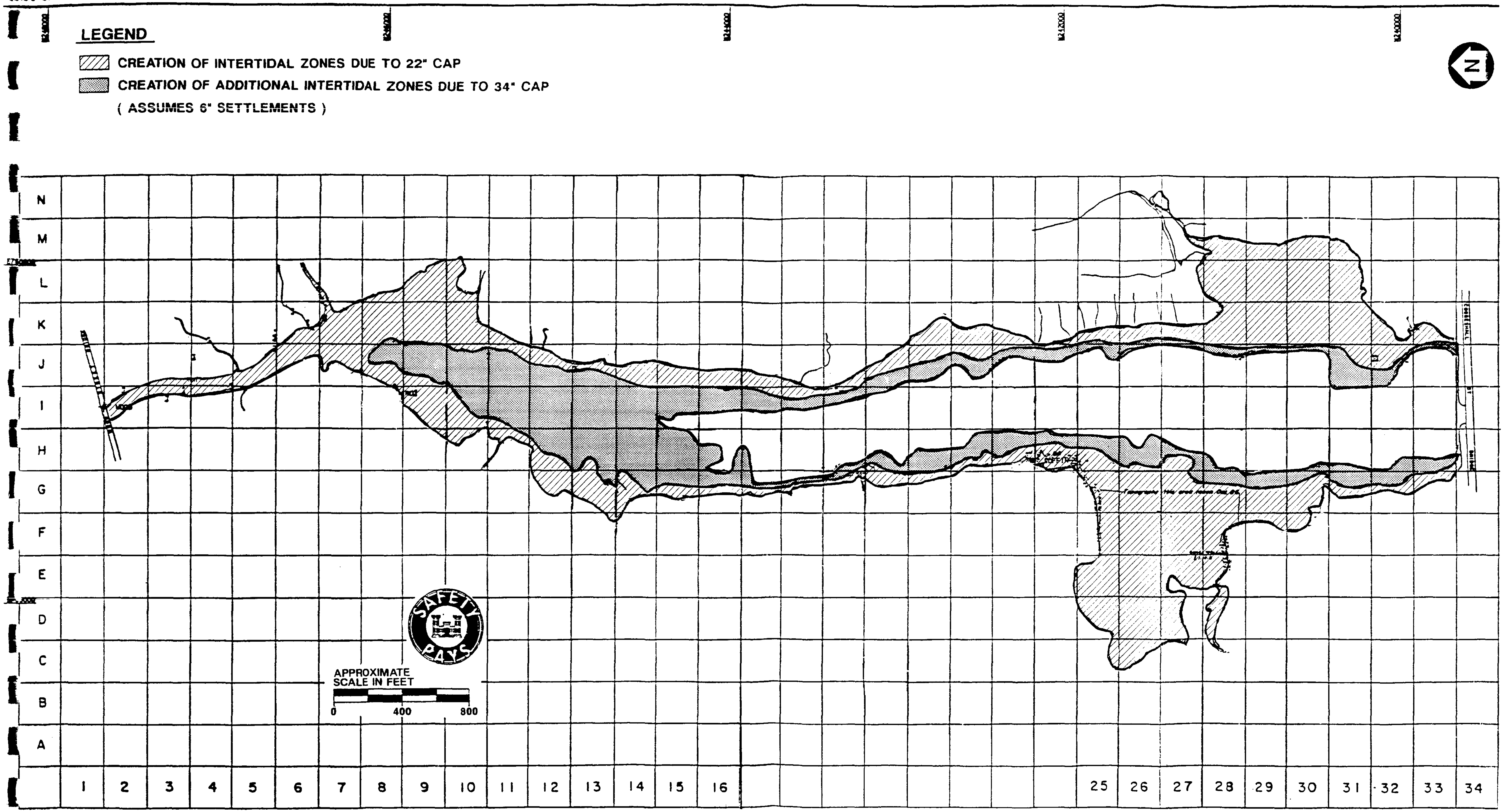

FIGURE 7-9
CAPPING IMPACTS TO ESTUARY
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

The estuary capping alternative (as described) does not cover any vegetated wetland areas along the eastern shoreline. Most of this wetland is above +3 feet MLW and is only flooded at high tide (USACE-NED, 1990).

Because it is anticipated that some of the capping material will shift or be resuspended in the water column due to currents, tidal action, or other erosional forces, a maintenance program would be designed to ensure cap integrity. This program should anticipate the deposition of approximately 10 percent of the total material every five years. Hydrographic surveys would be used to identify those areas requiring this additional material.

Flood storage capacity should not be significantly affected because most of the cap would be placed below 2 feet National Geodetic Vertical Datum. This elevation is exceeded only in the fringe areas where the cap is tied into the shoreline (Otis, 1990).

Dredging activities would be excluded in all areas to be capped. However, all areas designated for potential capping are currently outside active shipping waters; therefore, the cap should not interfere with those activities.

Capping sediments in excess of 10 ppm PCB will effectively reduce the public health risks associated with direct contact and incidental ingestion exposure to sediments. The reduction in risks results from the limited potential for contaminant exposure. This alternative, however, does nothing to reduce the toxicity and volume of contaminated sediment. Therefore, the long-term effectiveness of this alternative cannot be stated with certainty.

If the cap fails, the risks associated with potential exposure would be the same as those estimated under baseline conditions. These risks were estimated to be in excess of state requirements (10^{-5}) and within and in excess of the EPA target risk range.

7.3.4 Reduction in Mobility, Toxicity, and Volume

A cap over the sediment would not reduce the mobility, toxicity, or volume of the contaminants because no treatment is used. The multilayer cap would act as a physical barrier to prevent potential exposure and reduce PCB migration from the sediments into the water column. Mobility would not be permanently reduced and the contaminants could pose a future risk if cap failure occurs.

7.3.5 Implementation

7.3.5.1 Technical Feasibility

Constructability. Capping has been performed in numerous deep water locations with effective results. Installing a cap in the lower harbor/bay area can be accomplished using estalished placement techniques. However, installing a cap in the shallow estuary area will require modified placement techniques, which are unproven to date.

Special considerations are also required with respect to the cap thickness, due to the chemicals of concern within the hydrodynamic estuarine environment.

Reliability. Capping has been demonstrated as a reliable means of containing contaminants at various deep water locations. However, specific application of this technology within the shallow Acushnet River Estuary of New Bedford Harbor has not been demonstrated to date.

Support and Installation. Extensive coordination with the Harbor Master would be required to minimize the impacts of these remedial actions on the shipping activities. This would be neccessary primarily for activities involved within the lower harbor/bay.

Specific areas along the western shoreline within the estuary and eastern shoreline in the lower harbor would require access roadways to aid in deployment of the geotextile. The shoreline would require some regrading to provide a suitable area for the geotextile to be anchored.

Capping in the estuary would require hydraulic controls such that the water levels can be maintained at a sufficient depth to deploy the barges required for geotextile and sand placement. Because of the greater depths in the lower harbor/bay, these controls would not be necessary.

A temporary staging area would need to be constructed in each area to produce the sand slurry that can be pumped to the locations of deposition.

Ease of Undertaking Additional Remedial Actions. Undertaking additional remedial actions may involve enhancing the cap or removing the contaminated sediment under the cap. The latter remedial action would entail the removal and handling of a significant amount of material.

Monitoring Considerations. Environmental monitoring of the capping alternatives would involve hydrographic surveys before, during, and after the remedial activities. Further, sediment cores would be collected after placement of the capping material. The same environmental monitoring discussed for the no-action alternative is also included for these alternatives (see Subsection 7.2.1).

7.3.5.2 Administrative Feasibility

Coordination among the lead agency (i.e., USACE or EPA), the City of New Bedford, and the Commonwealth of Massachusetts will be important. Coordination would involve active communication, including formal and informal meetings, among these agencies at critical points in the remedial action process. Because all activities would be conducted on-site, no permits are needed for these alternatives.

Coordination would also be required between the lead agencies and the Harbor Master to assure minimal interference with the fishing industry during capping activities.

Because significant areas of estuary would be altered and the contaminated sediment would remain in place, resistance from various agencies and interest groups is anticipated.

7.3.5.3 Availability of Services and Materials

All activities and technologies proposed for these capping alternatives are general in nature and do not require highly specialized equipment or personnel. Vendors and contractors dealing with marine construction are readily available to perform the work described.

7.3.6 Cost

Tables 7-3 and 7-4 present the capital and O&M costs for Alternatives EST-2 and LHB-2. Separate cost components for these alternatives include hydraulic control structures, geotextile placement, sand placement, stone placement, and survey and monitoring, as well as indirect costs, contingencies, O&M costs, and the monitoring program. Costs for Alternatives EST-2 and LHB-2 are estimated at $46,121,000 and $59,792,000, respectively.

Figures 7-10 and 7-11 illustrate the cost breakdown for these alternatives. Costs for the hydraulic control structures in the estuary include a sheetpile structure located immediately adjacent to the Coggeshall Street Bridge. The structure would be tied to the eastern and western shorelines and would be constructed using barge-mounted equipment. The structure would have weirs and mechanically operated gates, as well as a walkway across the top.

TABLE 7-3
COST ESTIMATE: ALTERNATIVE EST-2
CAPPING
NEW BEDFORD HARBOR

ACTIVITY	COST
I. DIRECT COSTS	
A. Hydraulic Control Structure	$650,000
B. Geotextile Placement	$6,009,000
C. Sand Placement	$18,538,000
D. Stone Placement	$667,000
E. Survey and Monitoring	$575,000
DIRECT COSTS	$26,439,000
II. INDIRECT COSTS	
A. Health & Safety (@ 5%) Level D Protection [Activity B @ 25%]	$75,000
B. Legal, Administration, Permitting (@ 6%)	$1,586,000
C. Engineering (@10%)	$2,644,000
D. Services During Construction (@ 10%)	$2,644,000
E. Turnkey Contractor Fee (@ 15%)	$3,966,000
INDIRECT COSTS	$10,915,000
SUBTOTAL COSTS	$37,354,000
CONTINGENCY (@ 20%)	$7,471,000
TOTAL CAPITAL COSTS	$44,825,000
PRESENT WORTH COSTS - 1989 (@ 5% for 6 years)	$37,920,000
OPERATION AND MAINTENANCE COSTS (present worth @ 5% for 30 years upon completion)	$4,825,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000
TOTAL COST - ALTERNATIVE EST-2	$46,121,000

TABLE 7-4
COST ESTIMATE: ALTERNATIVE LHB-2
CAPPING
NEW BEDFORD HARBOR

ACTIVITY	COST
I. DIRECT COST	
A. Geotextile Placement	$5,400,000
B. Sand Placement	$18,027,000
C. Survey and Monitoring	$547,000
D. Shipchannel Dredging	$1,185,000
E. Dewater/Water Treatment	$4,535,000
F. Material Hauling	$104,000
G. CDF Construction	$4,833,000
DIRECT COSTS	$34,631,000
II. INDIRECT COST	
A. Health & Safety (@ 5%) Level D Protection [Activities: E,F] [Activity B @ 25%]	$300,000
B. Legal, Administration, Permitting (@ 6%)	$2,078,000
C. Engineering (@ 10%)	$3,463,000
D. Services During Construction (@ 10%)	$3,463,000
E. Turnkey Contractor Fee (@ 15%)	$5,195,000
INDIRECT COSTS	$14,499,000
SUBTOTAL COSTS	$49,130,000
CONTINGENCY (@ 20 %)	$9,826,000
TOTAL CAPITAL COSTS	$58,956,000
PRESENT WORTH COSTS - 1989 (@ 5% for 2 years for dredging, 6 years for capping)	$51,407,000
OPERATION AND MAINTENANCE COSTS (present worth @ 5% for 30 years upon completion)	$5,009,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000
TOTAL COST - ALTERNATIVE LHB-2	$59,792,000

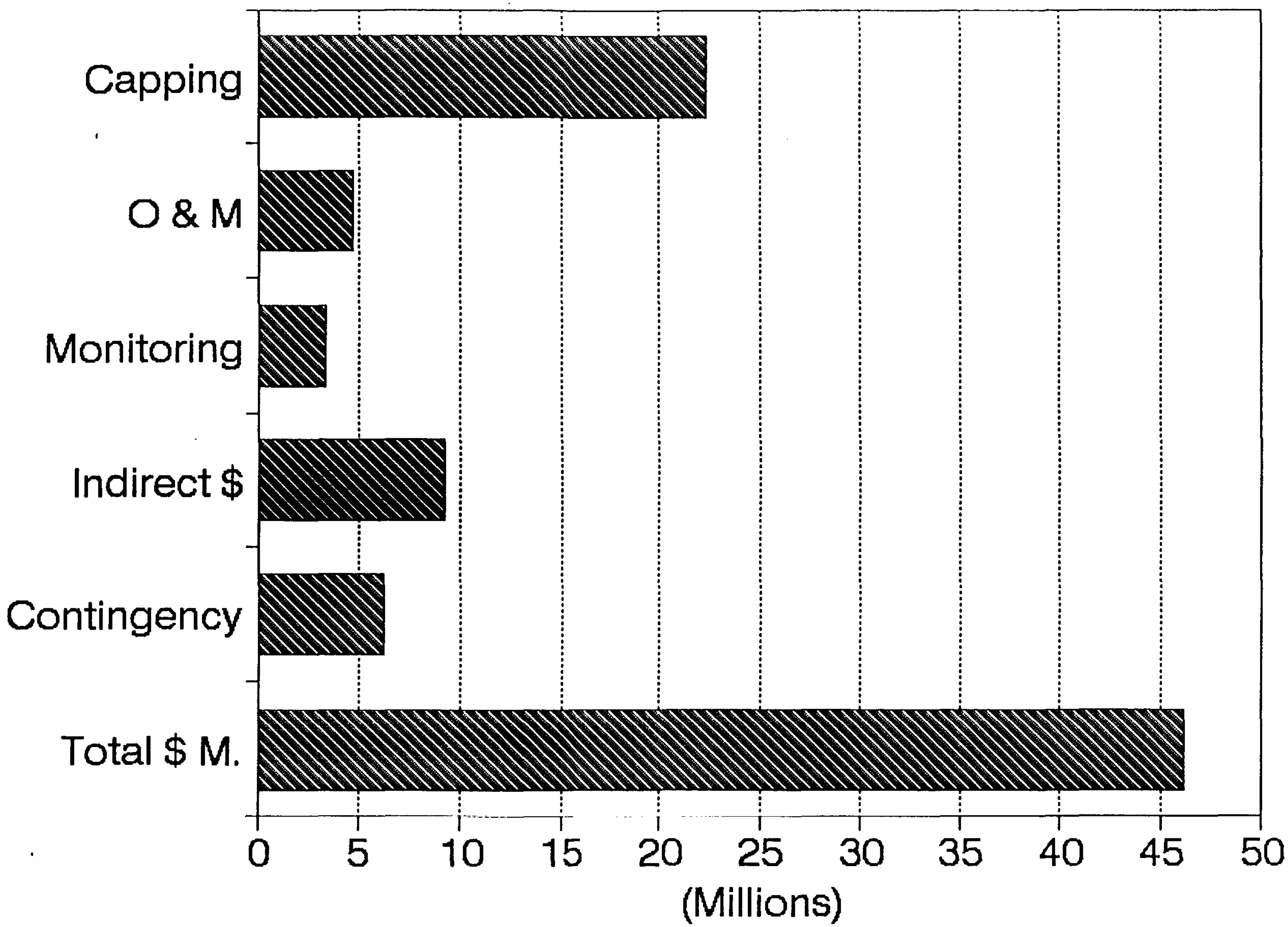

Figure 7-10

Cost Estimate EST-2
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

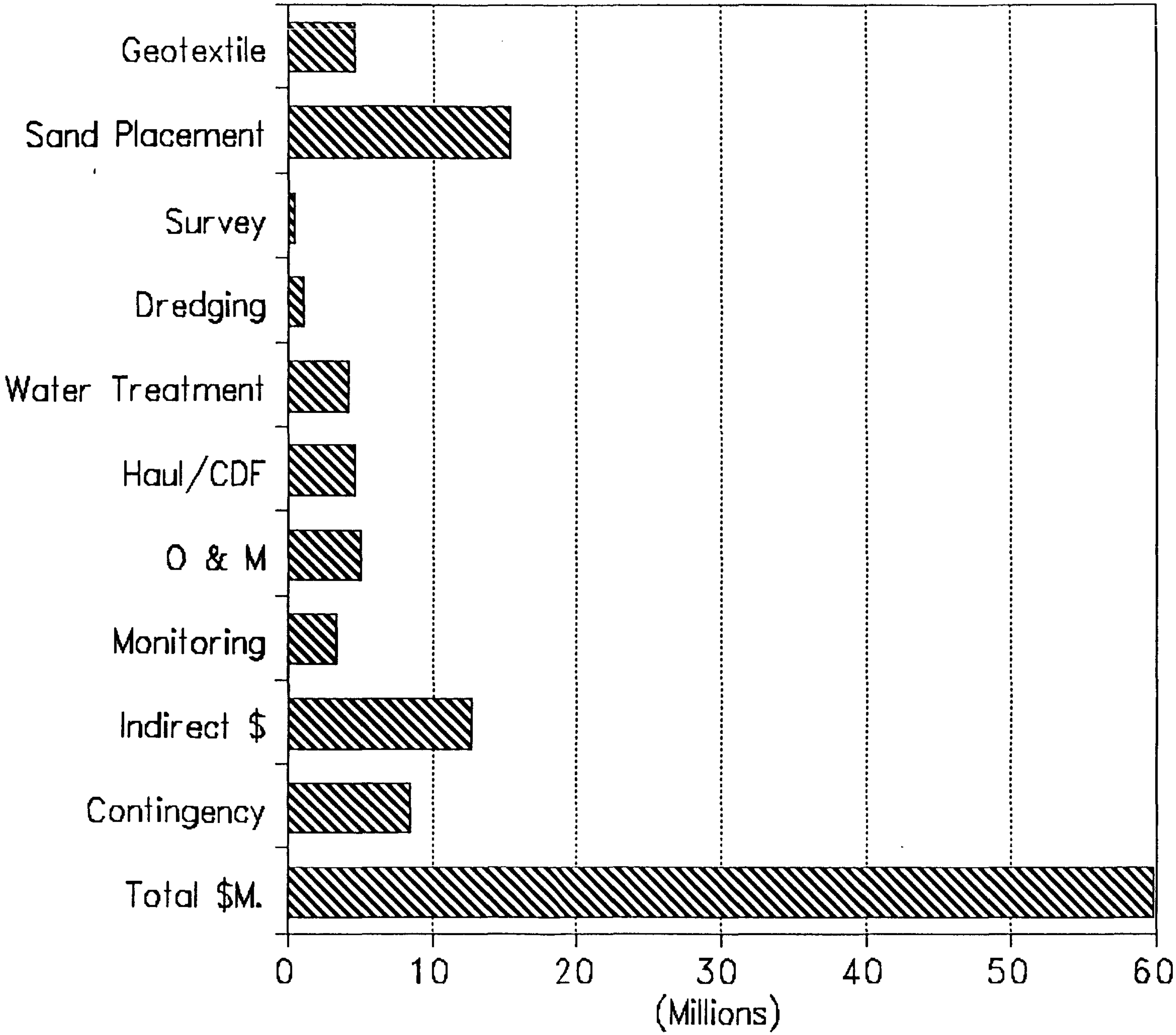

Figure 7-11

Cost Breakdown LHB-2
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

Geotextile placement costs involve all anticipated costs in preparation and placement of the fabric, including approximately 10 percent overlap. These costs are also included for the lower harbor/bay caps, although further geotechnical testing may determine that the geotextile is unnecessary. Costs for sand placement include all aspects of this task. Trucking, dredge, and barge deployment costs are included.

For the estuary, placement of stone armor in the vicinity of the Hot Spot Area is also included. A supply barge would be loaded by a front-end loader from a stockpile of crushed stone.

Finally, costs for the hydrographic surveys and sediment core collection are also included before, during, and after the remedial activities.

Additional costs include remediation necessary within the shipchannel areas within the lower harbor/bay where capping cannot be reasonably performed. The costs included herein are for dredging and disposal of the sediment in shoreline CDFs (as described for Alternative LHB-3).

A sensitivity analysis of the alternative components was conducted to determine which factors would significantly affect the overall costs. For these alternatives, the most costly component, sand placement, is most likely to change the total cost of the alternatives. The cost to create the sand cap is largely time-dependent, and is based on an estimate of approximately 57 months to complete the sand cap in the estuary and 55 months in the lower harbor/bay. These duration estimates could change due to unforeseen circumstances, such as weather or the need to bring in sand from sources located farther away. Therefore, a 25 percent increase in time required to complete this component of the capping operation was chosen to evaluate sensitivity of the total cost to this particular component. Results show a 9 percent increase in the total cost of Alternative EST-2, from $46 million to $50 million, and from $60 million to $64 million for Alternative LHB-2. Tables 7-5 and 7-6 illustrate the effects of this increase.

7.3.7 Compliance with ARARs

Chemical-specific ARARs are discussed in Subsection 4.2.2.1. Capping the estuary and the lower harbor/bay would be designed to meet the TCL of 10 ppm PCBs (see Section 4.0). This alternative would reduce the likelihood of migration of contaminants within the estuary and harbor, and would reduce accessibility to hazardous contaminants. The TEMPEST/FLESCOT model was not used to project water column PCB concentrations in the estuary or the lower harbor/bay. However, because initial conditions for the remedial action runs are based on achieving the 10-ppm TCL, results similar to those attained for the

TABLE 7-5
SENSITIVITY ANALYSIS: ALTERNATIVE EST-2
CAPPING
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)
DIRECT COSTS		
A. Hydraulic Control Structure	$650,000	$650,000
B. Geotextile Placement	$6,009,000	$6,009,000
C. Sand Placement	$18,538,000	$21,288,000
D. Stone Placement	$667,000	$667,000
E. Survey and Monitoring	$575,000	$575,000
TOTAL DIRECT COSTS	$26,439,000	$29,189,000
TOTAL INDIRECT COSTS	$10,915,000	$12,042,000
CONTINGENCY	$7,471,000	$8,246,000
TOTAL CAPITAL COSTS (present worth)	$37,920,000	$41,855,000
O&M/MONITORING (present worth)	$8,201,000	$8,201,000
TOTAL COST (present worth)	$46,121,000	$50,056,000

1. Increase cost of sand placement

TABLE 7-6
SENSITIVITY ANALYSIS: ALTERNATIVE LHB-2
CAPPING
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)
DIRECT COSTS		
A. Geotextile Placement	$5,400,000	$5,400,000
B. Sand Placement	$18,027,000	$20,580,000
C. Survey and Monitoring	$547,000	$547,000
TOTAL DIRECT COSTS	$23,974,000	$26,527,000
TOTAL INDIRECT COSTS	$9,896,000	$10,945,000
CONTINGENCY	$6,774,000	$7,494,000
TOTAL CAPITAL COSTS (present worth)	$34,383,000	$38,039,000
O&M/MONITORING (present worth)	$8,067,000	$8,067,000
TOTAL COST (present worth)	$42,450,000	$46,106,000

1. Increase cost of sand placement

dredging alternatives would be expected. These model runs show that water column concentrations in the estuary after remediation would be 357 ng/L, decreasing to 44 ng/L by Year 10. At that time, the water column concentrations for the no-action scenario would still be in excess of 1,000 ng/L. The potential for contaminant migration would exist in the future if the integrity of the cap were compromised.

Construction and placement of the cap will trigger several federal and state location-specific ARARs for floodplains and wetlands. Section 404 of the CWA regulates the deposit of dredged or fill material into waters of the U.S. Capping activities are regulated under Section 404. USACE has responsibility for administering the Section 404 permitting process. Pursuant to Section 212(e) of SARA, permit requirements under Section 404 are waived for activities occurring on-site; however, compliance with the substantive standards must be achieved.

In addition to the USACE administration of Section 404 of the CWA, the Massachusetts Wetlands Protection Act and regulations at 310 CMR 10.00 apply to all activities occurring in wetlands or in the 100-foot buffer zone. Similar to the federal 404 permit, filing an NOI with the local conservation commission is waived for all on-site activities. However, the local commission should be apprised of proposed activities and given the opportunity to review the draft New Bedford Harbor reports. Compliance with all substantive requirements of 310 CMR 10.00 and with the Massachusetts Water Quality Certification requirements at 314 CMR 9.00 is also required for activities involving dredging in wetlands or waterways.

Placement of the cap will require compliance with the procedural requirements outlined in the Administration of Waterway Licenses (310 CMR 9.00). These procedures were promulgated for the protection of tidal, wetland, estuarine, and marine resources, as well as public rights of navigation. Procedures relevant to the implementation of the capping alternative are those concerning construction activities in high tide areas and lands in designated port areas.

Capping will only reduce the accessibility to hazardous contaminants in the sediments; therefore, preference for permanent treatment stated in SARA and the NCP, as well as the MCP, would not be achieved.

RCRA landfill closure regulations at 40 CFR 264.310 are appropriate to the design and care of the cap. RCRA closure requirements state that final cover be designed and constructed to accommodate settling, and the cover integrity should be maintained throughout the post-closure care period. The proposed containment system meets these requirements to the extent applicable and would be periodically monitored to assure its effectiveness.

All site activities, including monitoring, will be carried out pursuant to OSHA standards (i.e., 29 CFR 1904, 1910, and 1926) and Massachusetts Right-to-Know regulations (see Subsection 4.2.2.3).

7.3.8 Overall Protection of Public Health and the Environment

The containment of contaminated sediment in the estuary and lower harbor/bay will effectively reduce the potential for direct contact exposure and limit the source of PCB contamination in surface water and biota. Public health and ecological risks will decrease after construction and placement of the containment system. Surface water and biota concentrations are expected to decrease as a result of containment actions. Based on modeled predictions, PCB concentrations in the surface water will decrease and approach the AWQC. Likewise, residual PCB concentrations in biota will approach the FDA tolerance level. However, because this alternative does not reduce the toxicity or volume of contaminated sediment, potential exists for significant risks to biota, public health, and the environment if the containment system fails. Public health risks, similar to those estimated under baseline conditions, could result if shoreline sediments become exposed in the future. Potential ecological risks would also result from a failure in the contaminant system. However, these risks would be a fraction of the location and amount of failure experienced.

Severe ecological impacts are expected during the construction of the containment system. The benthic community would essentially be destroyed as capping material is placed over the contaminated sediments. The time required to fully recolonize this area is not known.

7.4 ALTERNATIVES EST-3 AND LHB-3: REMOVAL AND ON-SITE DISPOSAL

7.4.1 General Description

Alternatives EST-3 and LHB-3 entail dredging 528,000 cy of sediment from the estuary and 398,000 cy from the lower harbor/bay and transporting it to preconstructed CAD cells and CDFs along the shoreline of the Acushnet River Estuary and New Bedford Harbor (Figures 7-12 and 7-13). The sediment volumes to be remediated in the estuary and the lower harbor/bay are based on the 10-ppm TCL (see Sections 3.0 and 4.0). Supernatant water from gravity settling in the CDFs would be treated before discharge to New Bedford Harbor.

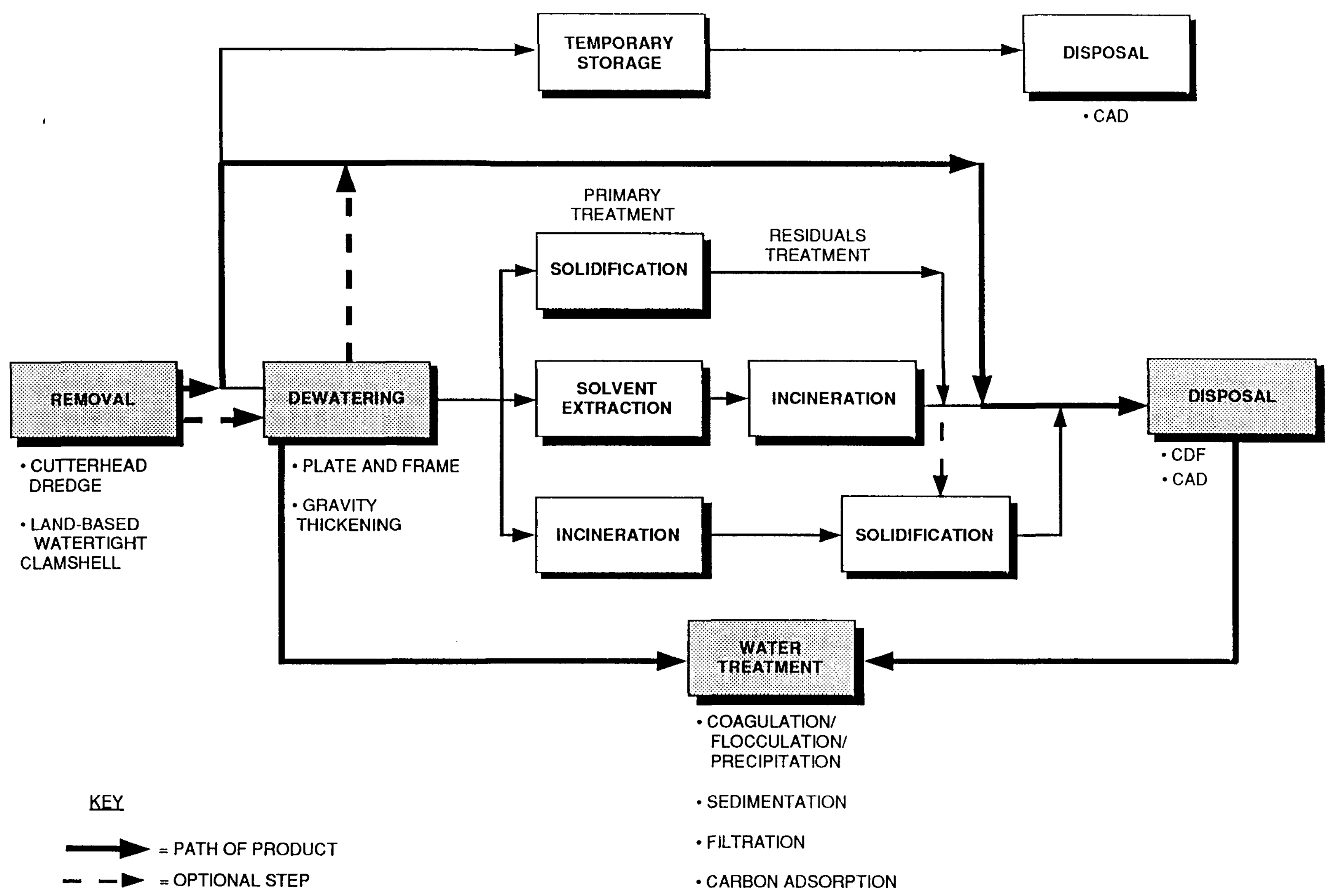

FIGURE 7-12
EST-3 AND LHB-3 DREDGE / ON-SITE DISPOSAL
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

dredging alternatives would be expected. These model runs show that water column concentrations in the estuary after remediation would be 357 ng/L, decreasing to 44 ng/L by Year 10. At that time, the water column concentrations for the no-action scenario would still be in excess of 1,000 ng/L. The potential for contaminant migration would exist in the future if the integrity of the cap were compromised.

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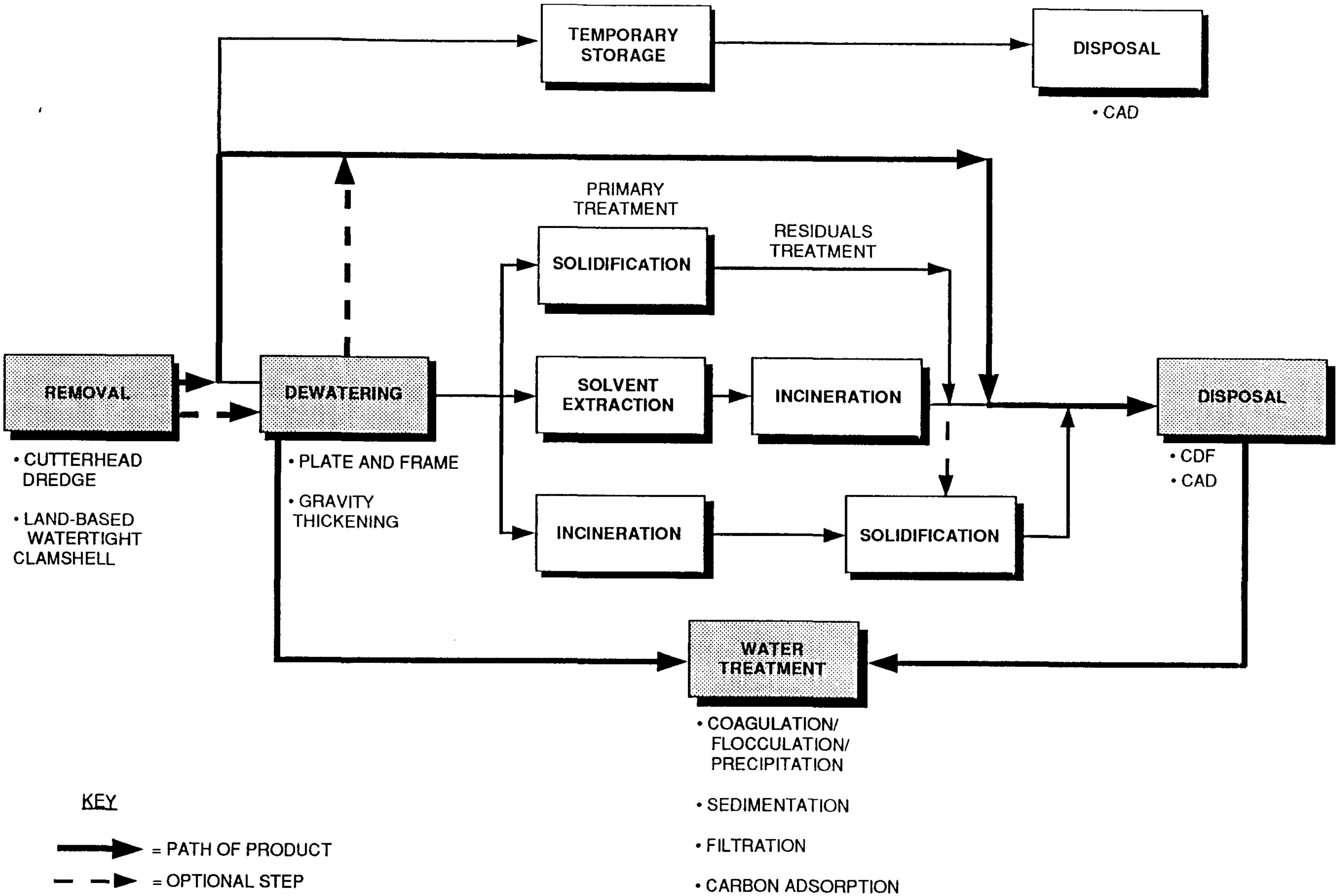


FIGURE 7-12
EST-3 AND LHB-3 DREDGE / ON-SITE DISPOSAL
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

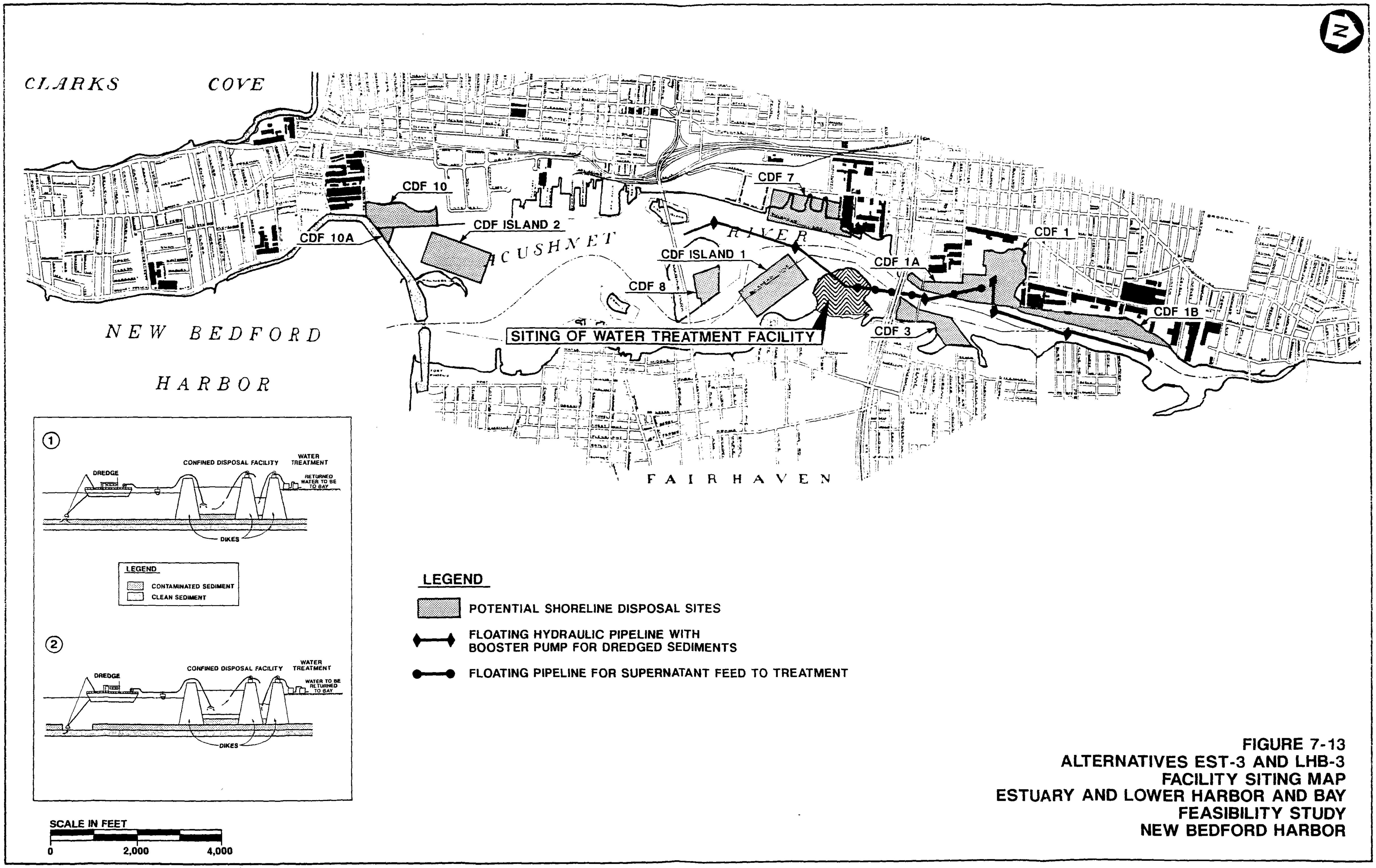


FIGURE 7-13
ALTERNATIVES EST-3 AND LHB-3
FACILITY SITING MAP
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

In an effort to further consolidate the material, thereby significantly reducing the number of CDFs required, an option under these alternatives would be to pump dredged sediments to a facility for mechanical dewatering and water treatment before disposal. To differentiate between the two processes, the labels EST-3d and LHB-3d will be used to identify the alternatives using mechanical dewatering.

The following paragraphs are detailed descriptions of the remedial actions comprising Alternatives EST-3 and LHB-3. Following the individual components are process flow diagrams for the alternatives. Figure 7-14 is a process flow diagram of Alternatives EST-3 and LHB-3.

Dredging. Sediment would be removed using a cutterhead dredge. The cutterhead dredge is recommended for use in the estuary and the lower harbor/bay based on results of the pilot dredging study (USACE-NED, 1990). A watertight clamshell dredge would need to be used in shoreline areas of the lower harbor/bay.

Operational procedures were developed by USACE during the dredging pilot study. These procedures optimize various factors associated with dredging. Cutterhead speed, swing speed, and duration of dredging times may be altered to minimize resuspension and subsequent migration of contaminated sediment. USACE recommended that the following operating procedures for the cutterhead dredge be used when removing New Bedford Harbor sediment from the estuary (USACE-NED, 1990):

Operating Time:	3 to 4 hours/day
Number of Passes:	2
Width of Cut:	60 feet (approximately)
Rate of Advance:	11 feet/hour (first pass)
	25 feet/hour (second pass)
Production Rate:	35 cy/hour (first pass)
Percent Solids: (in slurry)	2 to 4 percent

In areas where the water is deeper (i.e., the lower harbor), the operating period could be extended.

Silt curtains as an additional dredging control in preventing migration of resuspended sediment may not be necessary based on results of the pilot dredging study (USACE-NED, 1990). No significant sediment plumes were observed moving away from the dredgehead. However, resuspension of a considerable amount of sediment was observed during installation, positioning, and removal of the silt curtain during the pilot study (USACE-NED, 1990). If chemical and TSS monitoring indicates that silt curtains are needed during the dredging operations, they will be available on-site.

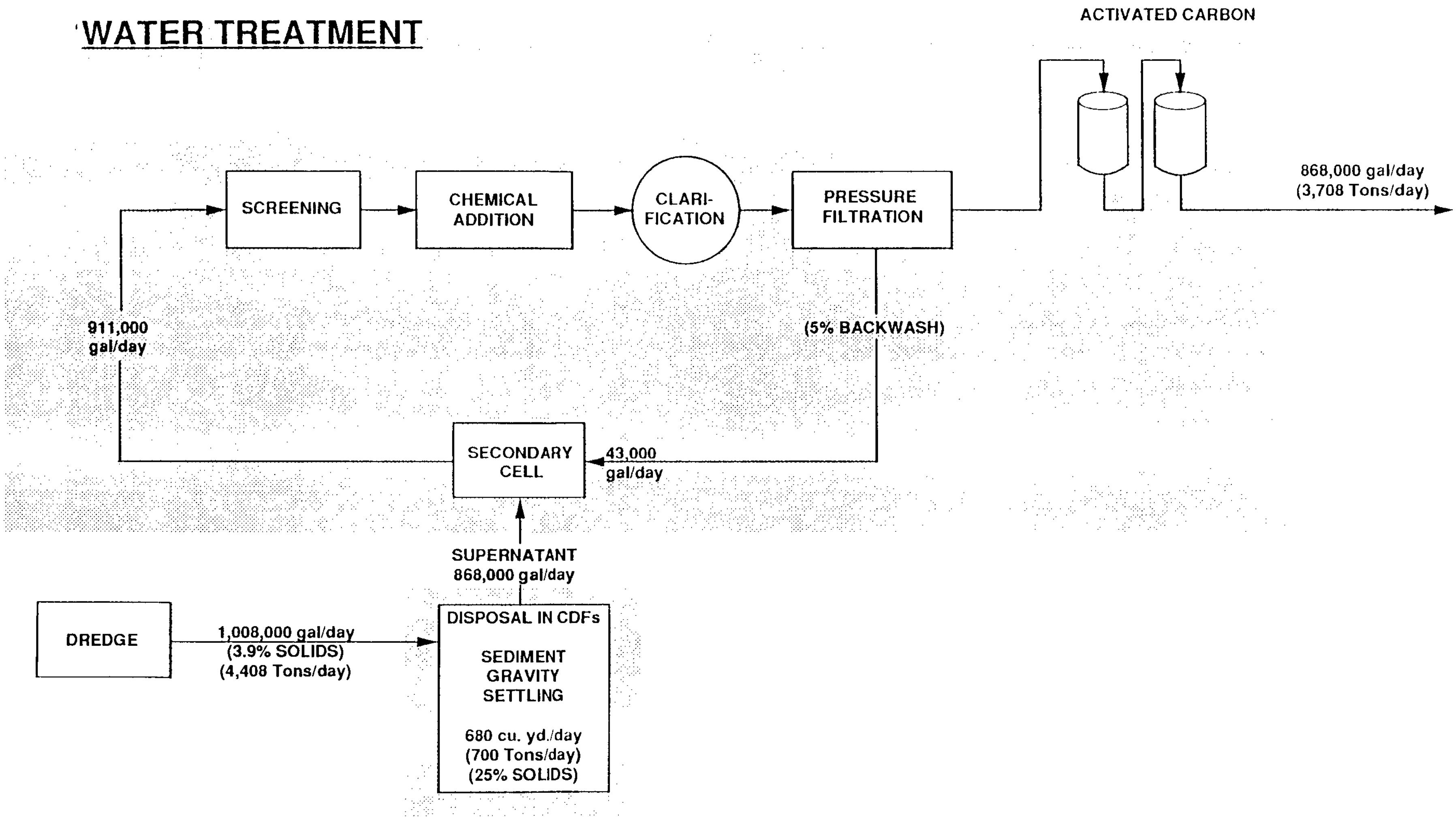


FIGURE 7-14
ALTERNATIVES EST-3 AND LHB-3
MASS BALANCE
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

Based on the recommended operating procedures for the cutterhead dredge, approximately 1,900 operational days (at 3 to 4 hours per day) would be required to remove 528,000 cy of sediment from the estuary, and 1,400 days to remove 398,000 cy from the lower harbor/bay. (Water depths in the lower harbor/bay may shorten the time required by extending the daily operational hours beyond 3 to 4 hours.) These estimates assume two dredges would each operate for approximately 4 hours per day and incur 20 percent downtime due to inclement weather or mechanical problems, such as clearing obstructions from the cutterhead. The dredge slurry was estimated to contain 2 to 4 percent solids (3.9 percent solids are used in the process flow diagram based on recommended operational procedures of 40 grams per liter from USACE).

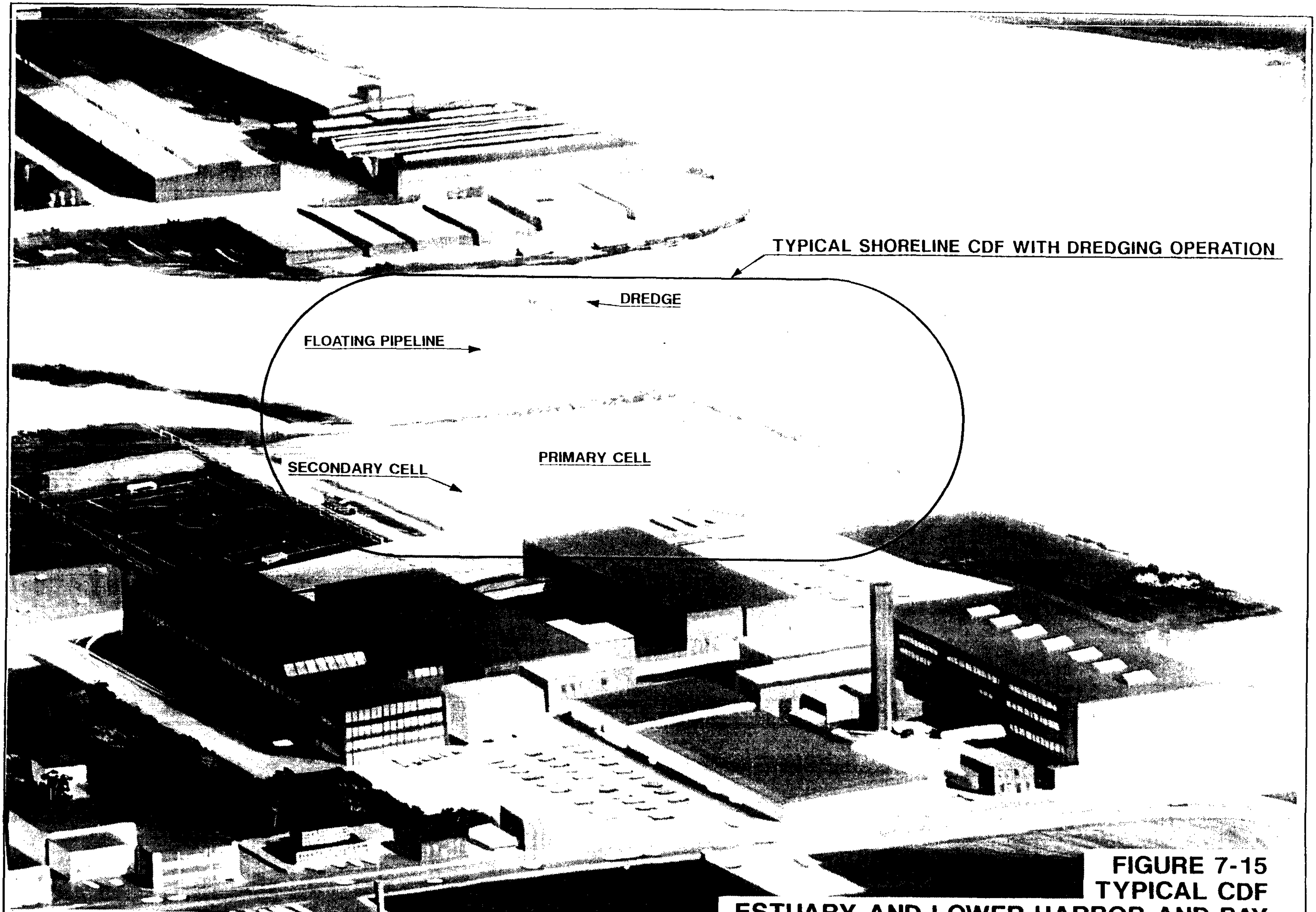
The dredged sediment would be transported to the dewatering facility or CDF by a floating hydraulic pipeline and/or a hopper barge or scow. The pipeline would be up to 20,000 feet long and may require booster pumps to move the dredged material. USACE recommended using standard polyethylene dredge pipe to transport the dredged sediment (USACE-NED, 1990). A hopper barge or scow would be used in the harbor where the floating pipeline might interfere with ship traffic.

Disposal. The dredged sediment would be discharged as an approximately 3.9 percent solids slurry into the disposal sites. A diffuser submerged below the water and attached to the effluent end of the pipeline would be used to facilitate settling of the dredged sediment by reducing the exit velocity and, therefore, the turbulence of the discharged material. A diffuser tested by USACE during the pilot study was found to be effective.

The sites identified for the disposal of New Bedford Harbor sediment include two types of facilities conceptualized in the FS report (NUS, 1984a):

- CDFs constructed along the shoreline or within the harbor, as identified in the NUS report and illustrated in Figure 7-15
- submerged CAD facilities that could be located in the estuary north of the Coggeshall Street Bridge and in selected areas of the lower harbor (e.g., between Marsh and Popes islands)

These sites include CDFs 1, 1a, 3, 7, 4, 8, Island CDF 1, and the CAD cells identified by USACE in the estuary. All these facilities would be required to accommodate the sediment dredged to 10 ppm if no mechanical dewatering were employed.



NOT TO SCALE

FIGURE 7-15
TYPICAL CDF
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

The CDFs would be constructed in a manner that best uses the available area with minimum disruption of commerce and harbor traffic. Design criteria would consider local sediment characteristics. Based on geotechnical investigations in the vicinity of the proposed CDFs, the disposal facilities would be constructed as described in Subsection 5.3.3.

Fences will be installed around the CDFs to prevent public access. Silt curtains will be used during construction to reduce migration of resuspended sediments.

Mechanical Dewatering (Alternatives EST-3d and LHB-3d). To conserve space and facilitate placement of the dredged sediment, mechanical dewatering may be used prior to disposal in the CDFs (Figure 7-16). The dredged sediment slurry would be pumped or transported by scow to a holding tank, where the dredged spoil would pass to a gravity clarifier/thickener. From there, the thickened slurry would be moved to a mechanical dewatering system. Bench-test dewatering results of New Bedford Harbor sediment using the plate and frame filter press technology indicate that a filter cake solids content of 50 percent by weight is achievable (OHM, 1988). Two large mobile units or one fixed-based unit would be able to sustain the daily dredge output of 280 cy (at 50 percent solids).

The dewatered sediment cake would be hauled to the disposal facilities by trucks (Figure 7-17). All the dewatered sediment could be held in CDFs 1 and 4, the estuary CAD cells for Alternative EST-3d, and CDFs 10/10a and Island 2 for Alternative LHB-3d. The CDFs would not require the sheetpile walls and secondary holding facilities if the sediment is mechanically dewatered, but would require temporary staging of a water treatment facility. Material pumped to the CAD cells would not require mechanical dewatering. Marsh Island was identified as a potential area to site such a facility. Effluent from the dewatering system would be recycled for water treatment, which is described in the following paragraphs. Figure 7-18 is a mass balance of Alternatives EST-3d and LHB-3d.

Water Treatment. Treatment of the CDF effluent and process wastewaters would be required before discharge back into New Bedford Harbor to remove PCB and heavy metals present in the dissolved and absorbed phases. Elutriate and saltwater batch leaching tests conducted by USACE on composite estuary and Hot Spot Area sediment samples showed PCB concentrations of 460 ppb in the elutriate and 730 ppb in the leachate (Averett, 1988).

Concentrations of PCBs in the CDF discharge measured during the pilot study averaged 1.4 ppb for the dissolved phase and 10.7 ppb for the particulate phase (USACE-NED, 1990). These results indicate that modified or additional treatment of the CDF

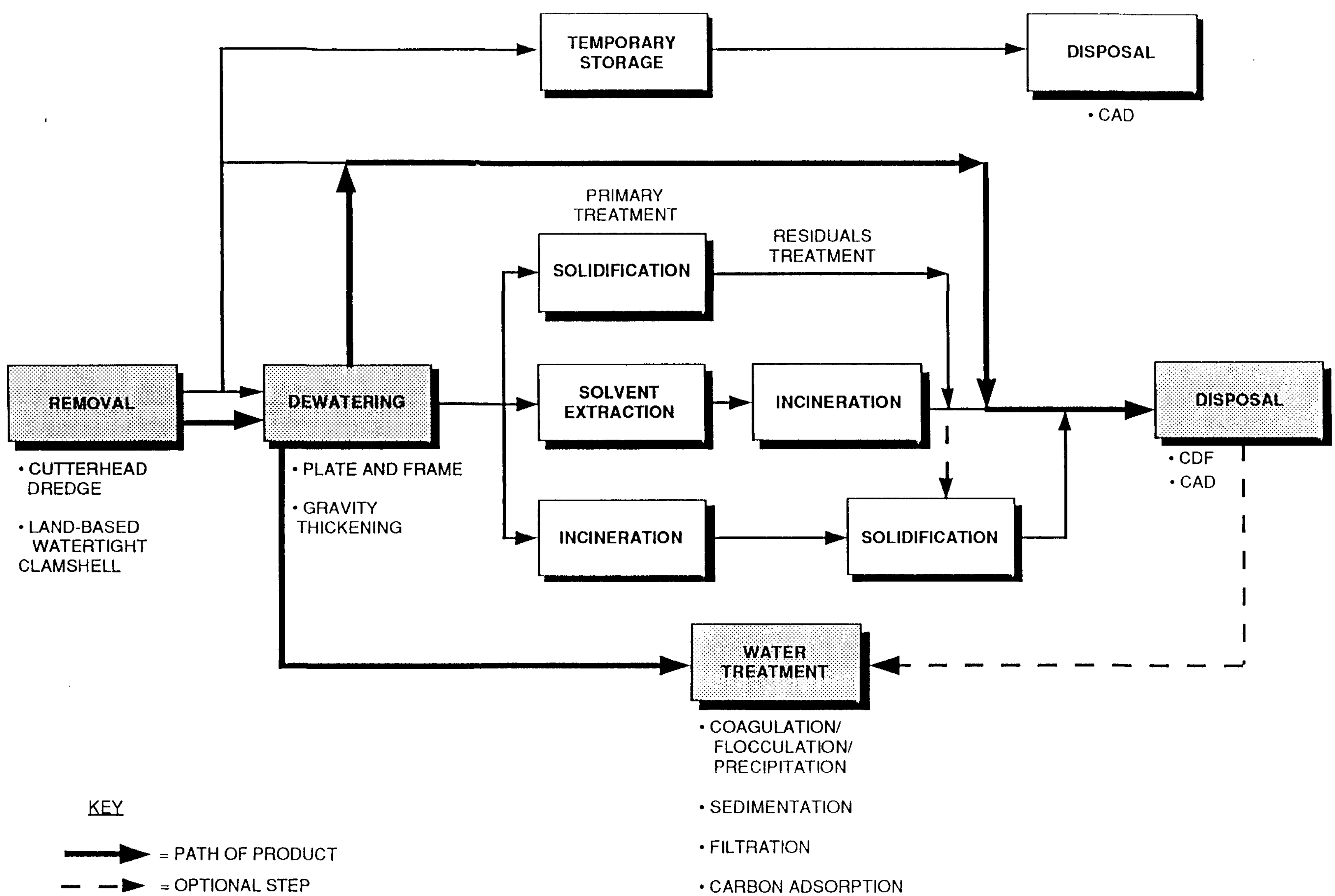


FIGURE 7-16
EST-3D AND LHB-3D DREDGE / ON-SITE DISPOSAL
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

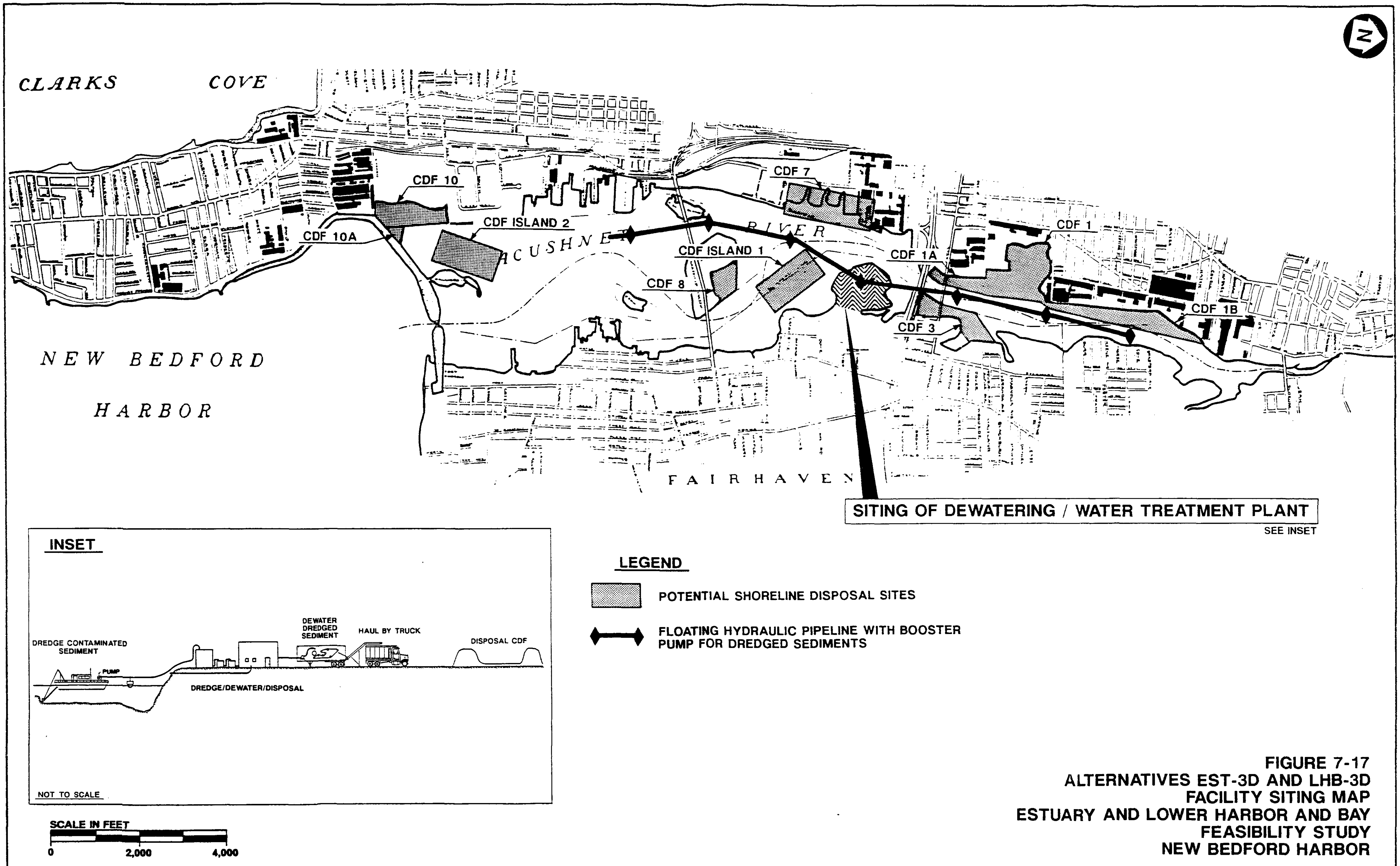


FIGURE 7-17
ALTERNATIVES EST-3D AND LHB-3D
FACILITY SITING MAP
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

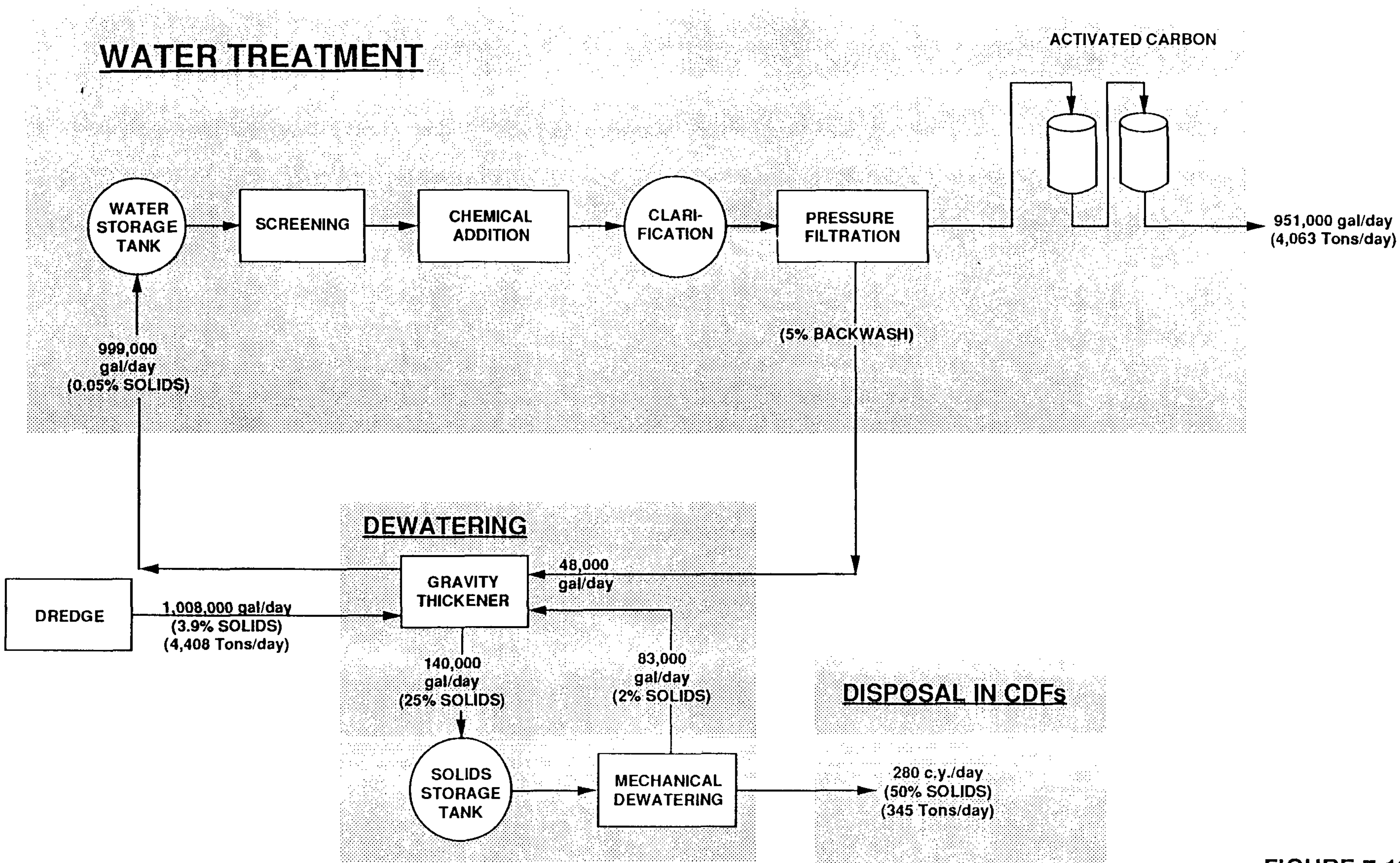


FIGURE 7-18
ALTERNATIVES EST-3D AND LHB-3D
MASS BALANCE
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

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effluent will occur to meet the water quality standards prior to discharge back to the harbor.

Effluent from the CDF would flow over a weir structure separating the primary cell from the secondary cell. As the water flows over the weir, coagulants would be added to promote flocculation and settling of suspended sediment. USACE tested cationic polymers as coagulants during the pilot study. Suspended solids levels measured at the weir averaged 97.3 mg/L TSS with a range of 9.9 to 895.4 mg/L TSS (USACE-NED, 1990). Results of these tests indicated that the polymer was effective in reducing suspended solids levels when the influent levels were high (i.e., in the 800-mg/L TSS range), but appeared to have only minimal impacts when the influent levels were low (i.e., in the 100-mg/L TSS range) (USACE-NED, 1990). This suggests that use of cationic polymers may only be appropriate for periods of high influent solids, such as when the CDF has reached its volume capacity and there is minimal retention time for settling of the dredged material slurry. USACE recommended that inorganic coagulants (e.g., alum, ferric chloride, and lime) be evaluated prior to final design of the water treatment system (Averett, 1989). These coagulants could be used alone or in conjunction with polymers. Chemicals low in toxicity to marine biota will be used for coagulation.

USACE estimated that a solids content of 70 mg/L could be achieved in the CDF effluent following chemical clarification. TSS measured during the pilot study in the CDF discharge effluent averaged 75.1 mg/L. PCB concentrations associated with this effluent were 1.4 and 10.7 ppb for the dissolved and suspended fractions, respectively (USACE-NED, 1990).

CDF effluent from the secondary cell would be treated to remove dissolved PCBs and metals. The treatment system would consist of carbon adsorption or UV/peroxide units preceded by sand (or similar) filtration units. The filtration units would be necessary to remove the suspended solids remaining after chemical clarification, thereby preventing clogging of the treatment units. Both carbon adsorption and UV/peroxide treatment of CDF effluent were evaluated during the pilot study. CDF effluent was passed through coarse sand filters prior to treatment. USACE indicated that use of these filters alone may have contributed to the low efficiency of the carbon adsorption unit by allowing a substantial fraction of PCBs absorbed to colloidal particles to pass through the filter and the carbon column (Averett, 1989). USACE recommended the use of microfilters to remove PCBs adsorbed to colloidal particles, thereby increasing the efficiency of the carbon column (Averett, 1989).

Results of the USACE studies indicate that both carbon adsorption and UV/peroxide treatment appear to be effective methods for the removal of dissolved PCBs in wastewater streams down to levels approaching 1 ppb (Averett, 1989). However, additional tests are needed to optimize the efficiency of carbon adsorption and to address potential adverse effects to biota from peroxide residuals.

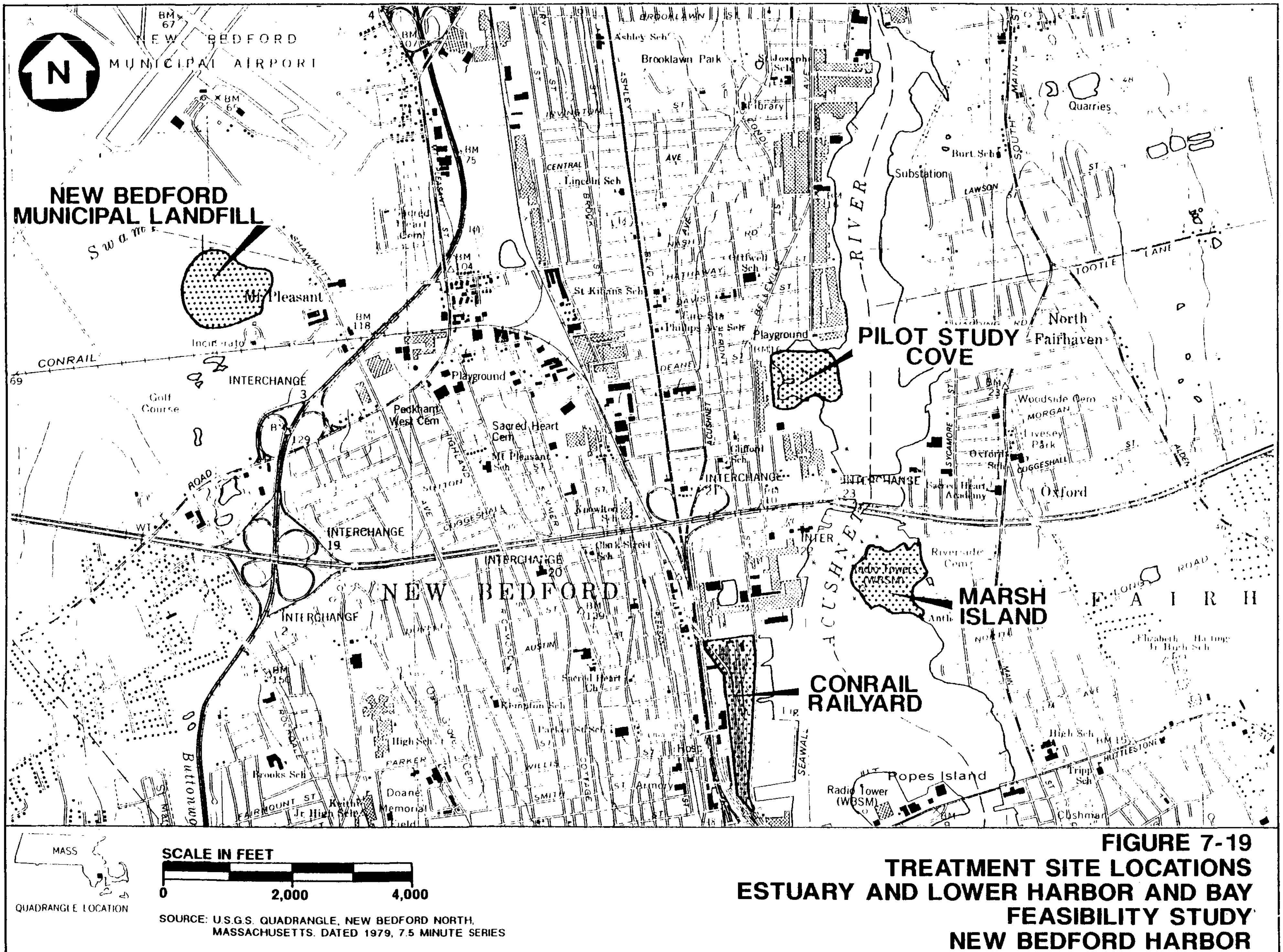
<u>Treatment Site Locations</u>. To assess the feasibility of the treatment alternatives, sufficient land area must be available to stage the dewatering and treatment equipment. Ideally, the treatment site selected should not be adjacent to a residential area. In addition, it may be more desirable to use areas that have already been environmentally degraded rather than those that have not been disturbed from the natural state.

Several suitable areas exist for sediment treatment in the New Bedford Harbor area (Figure 7-19). Each site is discussed in the respective order of feasibility to present an understanding of the area. The final site will be selected during remedial design; however, the most feasible site (the pilot cove area) is used for discussion herein.

The pilot study cove consists of approximately 29 acres and is located in the upper estuary on the western shore immediately north of the Coggeshall Street Bridge. A CDF was constructed in the cove to contain dredge spoils from pilot study activities and is also anticipated to contain the Hot Spot Area sediments. Sufficient land capacity (i.e., approximately 4.9 acres) also exists adjacent to the CDF to site water or sediment treatment equipment, unless mobile incinerators are used. The mobile incinerators require more area than is available adjacent to the cove; therefore, another site would need to be considered. The pilot study cove is preferred for remedial activities in the estuary because of an existing CDF that can be used for primary dewatering, and because it is located within the estuary boundaries. This site would require a shorter distance for the dredged material to be pumped.

Marsh Island is located along the Acushnet River, adjacent to the Riverside Cemetery in Fairhaven. The island, consisting of approximately 15 acres, was constructed out of dredged spoils. Currently, the island is vacant except for a radio tower. The Marsh Island site is a feasible location for treatment activities because of its size and location (i.e., adjacent to the estuary). Site preparation activities would be more extensive than for the pilot study area where equipment has already been staged (during that study). The use of this site would require pumping the dredged sediment an additional 2,000 feet from the pilot study area.

The Conrail Railyard consists of approximately 20 acres and is located on the New Bedford side of New Bedford Harbor. This site was historically used for transporting and unloading bulk



SOURCE: U.S.G.S. QUADRANGLE, NEW BEDFORD NORTH, MASSACHUSETTS. DATED 1979, 7.5 MINUTE SERIES

FIGURE 7-19
TREATMENT SITE LOCATIONS
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

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PCB fluid. The site has documented PCB contamination and is currently not in use. It is a feasible location for treatment activities because of its size, location (i.e., adjacent to the estuary in an industrial area), and current level of contamination. Preparation of this site would include removal of numerous railroad tracks. Also, PCB-contaminated soils would need to be removed during site preparation activities. The use of this site would require pumping sediment an additional 2,500 feet under the Coggeshall Street Bridge.

The New Bedford Municipal Landfill is the existing landfill for the City of New Bedford. It is located in the northwestern part of the city and is currently near capacity. The top area of the landfill is approximately 25 acres; sufficient land is available to perform sediment treatment and not interfere with landfilling operations. The advantage to using this landfill area is that it is located a considerable distance from residential areas. The disadvantages are that it would require substantial site development work, a dewatering facility adjacent to the harbor would need to be constructed, and the sediment would need to be transported from the dewatering facility to the landfill via local highways.

Wetlands Remediation. Remediating the entire estuary to the 10-ppm TCL would require the removal of an additional 43 acres of wetlands along the eastern shoreline consisting of intertidal, vegetated marsh above +4 feet MLW. If the additional 139,000 cy of sediment were not removed, it could potentially act as a source of PCB contamination for the newly exposed clean sediment in the estuary and the water column during tidal fluctuations.

Dredging the sediment in the wetlands would occur as previously described for the rest of the estuary. The sediment removed would be transported to the CDFs for dewatering and disposal. Due to the increased volume of sediment to be disposed of, all or part of the sediment from the estuary, wetlands, and lower harbor/bay would need to be mechanically dewatered prior to disposal, because CDF capacity is limited.

To mitigate the loss of these productive wetland habitats and to reduce the chance of erosion, new saltmarsh would be created. Clean sediment would be placed by hydraulic dredge, clamshell, or dragline to raise the elevation of intertidal flats or subtidal areas to support regularly flooded low saltmarsh. The area would be revegetated with saltwater cordgrass and other species (i.e., sprigs or transplants). Water flow velocities in the estuary may need to be reduced during replanting to minimize the erosion of sediment and plants (IEP, Inc., 1988).

However, in the course of evaluating the clean-up of these wetland areas, an assessment was made comparing the potential adverse impacts of the wetlands acting as a continued source to the estuary with the benefits of their removal. Also considered in this assessment was the functional integrity of the wetland ecosystem, and the disruption of the habitat and feeding grounds of a wide variety of wildlife that this remediation would cause. Physical and chemical measurements of selected biotic and abiotic features of the Acushnet River Estuary wetlands were taken and compared with a nearby control site. Results suggested that structural characteristics of the estuary wetlands have not been altered by the PCB contaminant levels present, and that these wetlands support a viable and productive community of organisms (IEP, Inc., 1988; and Sanford, 1987).

For purposes of this FS, a conclusion was reached that the benefits obtained by remediating the wetlands are outweighed by the adverse environmental impacts associated with extremely disruptive dredging. Therefore, these alternatives and those following will not consider remediation of the additional 43 acres of wetlands in the estuary.

7.4.2 Short-term Effectiveness

Risk to the community is expected to be minimal during remediation. The dewatering and disposal areas are generally located in commercial or industrial zones of New Bedford. Use of fencing and on-site security personnel would preclude unauthorized entry to the area and would be effective in preventing the community from coming into direct contact with the contaminated sediment. Dredging is not expected to generate substantial levels of airborne or volatilized contaminants to which workers in adjacent areas would be exposed. An air monitoring program would be required during operation of the CDFs. Methods to reduce emissions, such as spraying the sediment with water or using a chemical dust suppressant, could be used if ambient levels threaten worker safety or public health.

Workers on-site during remedial activities would use personal protection equipment (i.e., respirators, overalls, and gloves) to minimize or prevent exposure to contaminants through dermal contact and the inhalation of airborne particulates or volatilized contaminants as a result of dredging operations (e.g., clearing debris from or unclogging the dredgehead) and dewatering the sediment.

Dredging is expected to cause some impacts to the environment. Flora and fauna currently residing within the 10-ppm target area below 4 feet MLW would be removed along with the sediment and destroyed during the dredging operation. Although it is expected that this area would rapidly reestablish itself, this process could be enhanced through a recolonization program. Results of the USACE pilot dredging study indicate that resuspension of contaminated sediment would be minimal when proper dredge operating conditions are used and that additional controls such as silt curtains would not be necessary. Average resuspension rates for the cutterhead dredge were 12 g/sec at the dredgehead with suspended solids levels in the water column returning to background within 400 feet of the operating dredge (USACE-NED, 1990). Transport of dredge material to the CDFs via a floating hydraulic pipeline is not expected to affect the environment; however, the pipeline would be continually monitored for leakage.

7.4.3 Long-term Effectiveness and Permanence

Removal of 528,000 cy of contaminated sediment in the upper estuary to achieve a 10-ppm residual sediment PCB concentration would remove a substantial mass of PCBs. An obvious benefit of this remedial action would be significant reduction in the water column PCB concentrations in the upper estuary and concurrent reduction in the flux of PCBs through the Coggeshall Street Bridge into the lower harbor. The net flux of total PCBs through the Coggeshall Street Bridge computed by the TEMPEST/FLESCOT model would be reduced from 42 kg/yr at Year Zero (immediately following remediation), to less than 1.5 kg/yr at Year 10. This can be compared to the 155-kg/yr net PCB flux for the no-action scenario, which was shown to remain essentially constant over the 10-year projection period (Battelle, 1990).

Figure 7-20 is a comparison of water column PCB concentrations in the estuary between the no-action and the 10-ppm remedial action alternatives. Average water column PCB concentrations in the upper estuary would be reduced from 357 ng/L in Year Zero to 44 ng/L by Year 10. This is a significant improvement over the no-action scenario, in which water column PCB concentrations of 2,010 ng/L in Year Zero would be reduced to 1,107 ng/L by Year 10 (Battelle, 1990). However, water column PCB concentrations in the estuary would still remain above the AWQC of 30 ng/L.

Remediation of the estuary to 10 ppm would also result in significant and consistent reduction of PCB flux in the lower harbor compared to the no-action scenario. Ten-year projections for the lower harbor show a loss of 360 kg of PCB mass for the no-action scenario and 920 kg as a result of remediating the estuary. The net flux of total PCBs through the Hurricane Barrier computed by the TEMPEST/FLESCOT model would be reduced from 70 kg/yr at Year Zero to less than 28 kg/yr at Year 10. This can be compared to the 105 kg/yr net PCB flux for the no-action scenario at Year Zero and 77 kg/yr at Year 10 (Battelle, 1990). These numbers suggest that it will take 10 years of no action to achieve the same reduced flux of PCBs to the outer harbor that can be obtained within the first year following remediation of the estuary to 10 ppm.

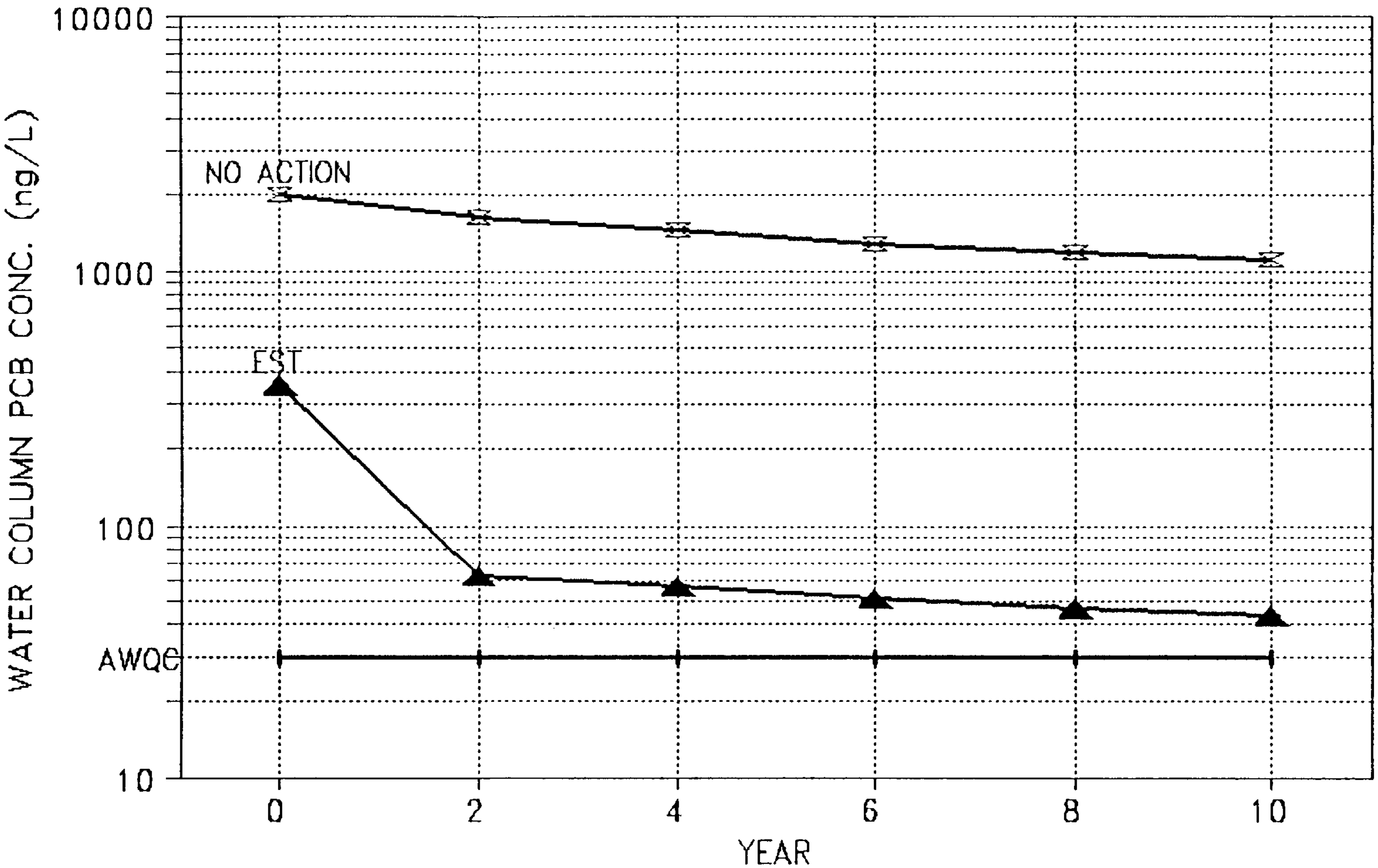

FIGURE 7-20
WATER COLUMN PCB
CONCENTRATIONS IN THE ESTUARY
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

Similar improvements in water column PCB concentrations can be achieved in the lower harbor as a result of remediating the estuary to 10 ppm. Figure 7-21 is a comparison of water column PCB concentrations in the lower harbor between the no-action and 10-ppm remedial action alternatives. Average water column PCB concentrations in the lower harbor would be reduced from 141 ng/L in Year Zero to 39 ng/L in Year 10.

The improvements on projected water column and sediment PCB concentrations in the lower harbor would be reflected in the biota. Remediation of the estuary to 10 ppm would result in a reduction in flounder PCB concentrations of between 45 and 50 percent; levels near the FDA tolerance level would decline to about half the tolerance level (Battelle, 1990). Projected biota responses in the outer harbor would be essentially the same as those discussed in Subsection 7.2.3.

Based on an average water column PCB concentration of 44 ng/L in the upper estuary at the end of the 10-year simulation, the MATCs would be exceeded for 25 percent of the marine fish, less than 5 percent of the crustaceans, 5 percent of the mollusks, and 15 percent of the algae. These numbers can be compared with the MATCs for the no-action scenario of 80, 35, 20, and 35 percent for the marine fish, crustaceans, mollusks, and algae, respectively. These results suggest that a significant reduction in the potential adverse effects to biota may be achieved by remediating the upper estuary.

The reduction in sediment PCB concentration and the associated pore water PCB concentration in the upper estuary would result in similar reductions in biota MATCs. For a sediment PCB concentration of 10 ppm, the MATCs would be exceeded for 10 percent of the marine fish (versus 95 percent for no action), 15 percent of the crustaceans (versus 65 percent), and 15 percent (versus 60 percent) of the mollusks.

Reduction in shoreline sediment PCB concentrations to 10 ppm will provide an adequate level of protection to public health. A 10-ppm PCB residual concentration was established as the TCL for the estuary and lower harbor/bay based on protecting young children (through age 6) from PCB exposure. Because children were considered the most sensitive population, risks associated with exposure to 10 ppm PCB by older children and adults will be lower than 10^{-5}.

Remediation of the lower harbor area to 10 ppm would provide additional although less significant improvements in the reduction of PCB mass in the bed sediment and in the net flux of PCBs through the Hurricane Barrier. Ten-year projections for the lower harbor show that remediation of the estuary to 10 ppm caused an initial PCB mass flux of 1,708 kg/yr in the lower harbor at Year Zero to be reduced to 788 kg/yr by Year 10, for a

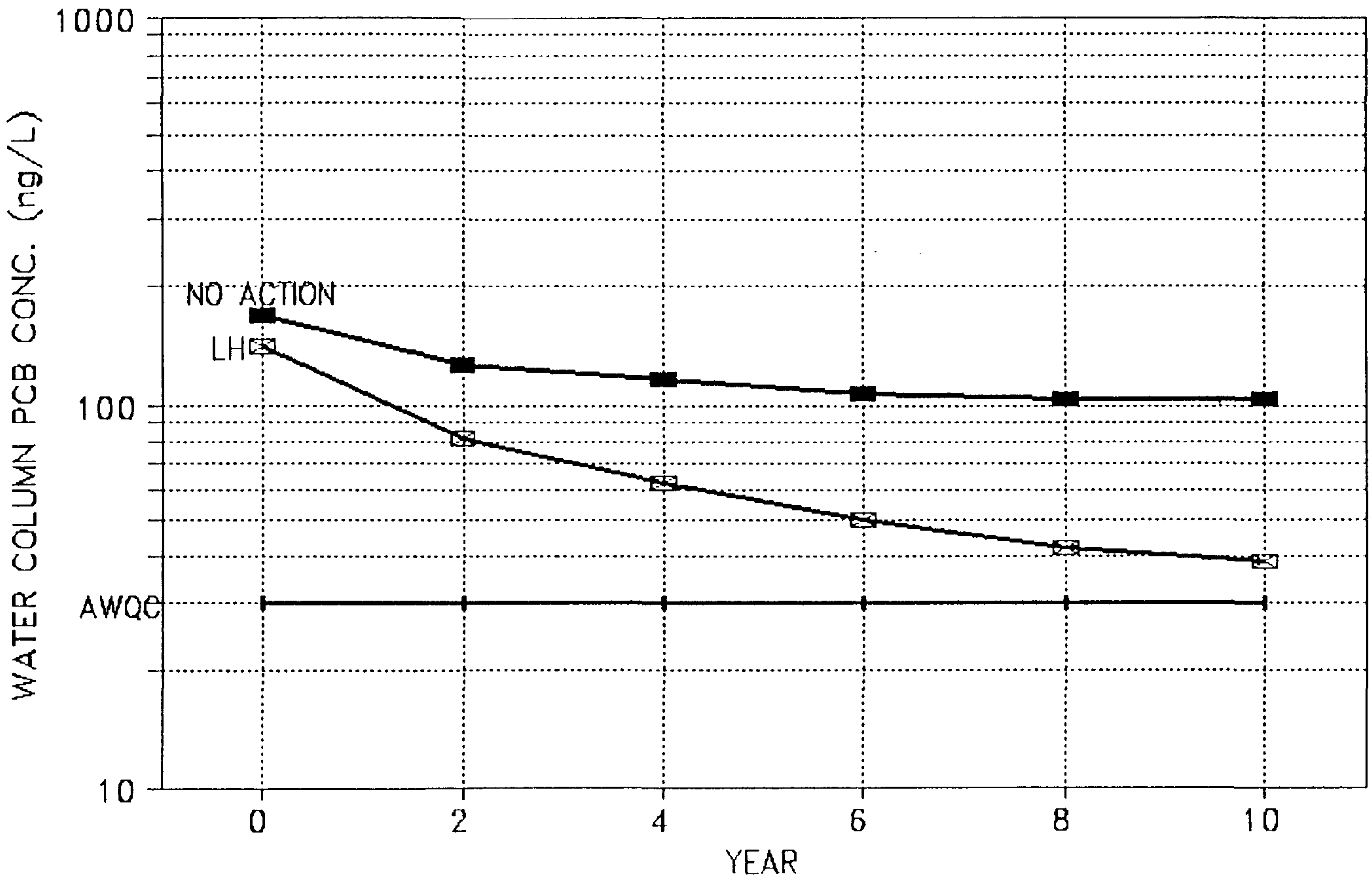

FIGURE 7-21
WATER COLUMN PCB CONCENTRATIONS IN THE LOWER HARBOR ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

net loss of 920 kg/yr. However, following remediation of the lower harbor to 10 ppm, an initial PCB flux mass of 870 kg/yr at Year Zero was reduced to 440 kg/yr by Year 10, for a net loss of 430 kg.

Declines in water column PCB concentrations also are not as significant. Figure 7-22 shows that water column PCB concentrations in the lower harbor following remediation of the estuary would be 39 ng/L at Year 10. However, remediation of the lower harbor would only reduce water column PCB concentrations to 29 ng/L at Year 10. Therefore, a significant remedial effort in the lower harbor would appear to provide a relatively insignificant improvement in water column PCB levels for this area.

A 10-year projection of the biota PCB concentrations following remediation of the lower harbor shows that PCB concentrations in flounder inhabiting this area decline about 65 percent. After 10 years, whole-body concentrations range from about 1.5 ug/g for young flounder to about 2.8 ug/g for flounder five years of age (Battelle, 1990). On an edible-tissue basis, these concentrations are equivalent to about 0.3 and 0.5 ug/g, respectively. Therefore, these projected concentrations are significantly below the FDA action limit (Battelle, 1990). For the outer bay area, the projected responses of flounder and lobster are essentially the same as those discussed in Subsection 7.2.3.

Remediation of the lower harbor would result in relatively little additional reduction in the probability that MATCs for biota would be exceeded in the lower harbor when compared with the results gained by remediating only the estuary.

As stated, shoreline sediment concentrations of 10 ppm PCB provide an adequate level of protection to public health. A 10-ppm PCB TCL was developed to be protective of contaminant exposure by young children (through age 6). Remediation of the lower harbor to 10 ppm PCB will provide additional reduction in public health risks, because current PCB concentrations in shoreline sediments in this area are in excess of this level.

7.4.4 Reduction in Mobility, Toxicity, and Volume

Disposal of the contaminated sediment in CDFs is expected to reduce the potential migration of PCBs and metals. However, the long-term performance cannot be assessed because potential exists for leachate migration from the CDFs. No reduction in mobility, toxicity, or volume of contaminants is achieved, because the sediment is not treated. If mechanical dewatering is not used, the volume of sediment to be disposed of would be larger than the volume dredged, because the solids content of

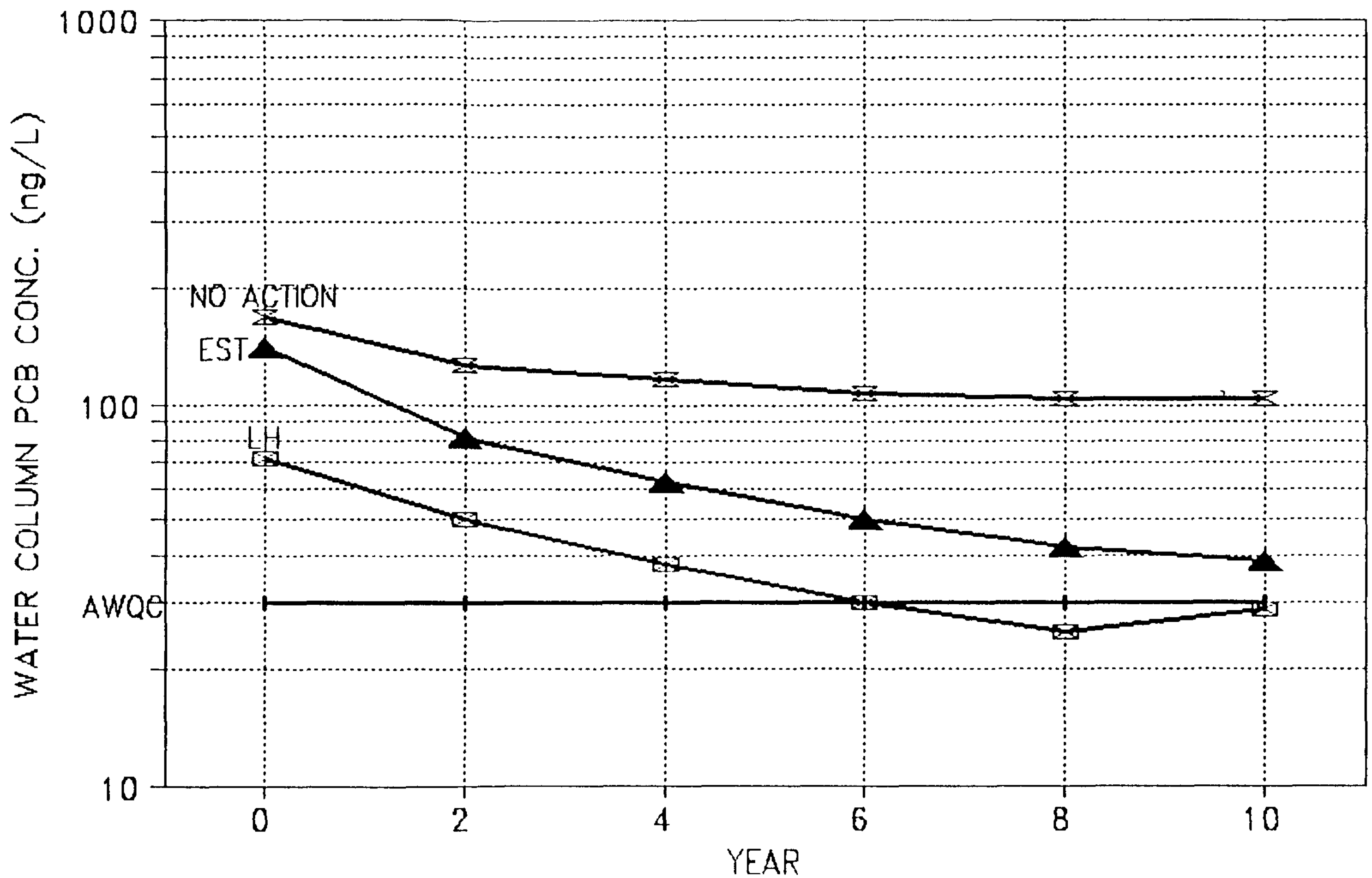

FIGURE 7-22
WATER COLUMN PCB CONCENTRATIONS IN THE UPPER ESTUARY AND LOWER HARBOR
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

the sediment following gravity dewatering would be lower than the solids content in situ.

7.4.5 Implementation

7.4.5.1 Technical Feasibility

Constructability. Dredging is a common operation and has been pilot-tested in the cove area of the Acushnet River Estuary. Based on results of the pilot test, a cutterhead dredge is recommended, and the operating parameters of the dredge were established so that sediment resuspension would be minimized.

Shoreline disposal sites are a demonstrated technology currently being used at various locations for the containment of dredge spoils. A small CDF was also constructed in the estuary as part of the USACE pilot study to demonstrate site-specific application of this technology.

The dewatering and water treatment technologies are well-proven for the intended application. Prior to final design, bench-scale studies would be required to determine equipment size, chemical dosage, and activated carbon requirements.

Reliability. Hydraulic dredging with a cutterhead dredge has been demonstrated to be a reliable technology for use in New Bedford Harbor. Delays are likely in the dredging operation due to inclement weather and downtime to remove debris along the shoreline areas.

Land acquisition for CDF construction may be a problem. Months were required to obtain access to the property from the City of New Bedford for the pilot study. Because the areas identified for staging of the water treatment facility and construction of CDFs have numerous owners, acquisition of the properties could be time-consuming.

Schedule delays may be encountered during construction of the CDF embankments if the embankment soils do not consolidate in a timely manner. Seventy-four days were necessary to sufficiently consolidate the first stage before the second stage was constructed in the pilot study. Wick drains would be used to enhance consolidation, as was used by USACE in the pilot study.

Support and Installation. Extensive coordination with the Harbor Master would be required during dredging activities to minimize or avoid impacts on commercial shipping traffic. Small tugs or workboats would be required to move the cutterhead dredge to designated areas within the harbor. The dredge removes the material and pumps it through a pipeline to the disposal site. This pipeline would float on the water surface and would be supported by pipe floats and/or pontoons. Support crews in workboats would be necessary for the inspection and maintenance of the pipeline to ensure its integrity.

Site preparation and land acquisition would be the most significant support requirements for the development of shoreline disposal sites. Access to the facilities would also need to be secured. For island siting of treatment facilities or CDFs, portable bridges may be required to provide truck access, or dredging may be required to provide scow access to the island.

Land acquisition and site preparation would also be required for construction of the dewatering facility, if a fixed facility is chosen instead of mobile treatment. Approximately 1 acre of land would be required for the facility, plus access for the support personnel.

Ease of Undertaking Additional Remedial Actions. Additional remedial actions may be required where there is unacceptable sediment resuspension with subsequent dispersion during dredging, unacceptable levels of contaminated leachate escaping from the disposal facility, or delayed times in sediment consolidation within the CDF for closure with associated air volatilization.

Sediment resuspension could distribute the contaminated sediments over an area greater than currently exists, causing cleanup to become more costly and requiring more material to be removed from the site. Results from the USACE pilot study carried out in the estuary indicate that resuspension of contaminated sediments during dredging can be minimized. Suspended solids levels measured adjacent to the operating cutterhead dredge averaged 80 mg/L, and had returned to background conditions (10 mg/L) 400 feet from the dredge. No increases in suspended sediments have been observed at any of the far-field sampling locations (e.g., Coggeshall Street Bridge and the Hurricane Barrier). Sediments in the estuary are similar to those in the pilot study; therefore, minimal resuspension is expected in the estuary. Because the sediments in the lower harbor/bay contain a larger fraction of sand (on average) than those in the estuary, use of the pilot study data for the harbor should be a conservative extrapolation, because sand settles out more rapidly than the smaller silt and clay size particles.

Contaminants leaching out of the shoreline facility back into the environment may require additional remedial actions. Data are being collected from the pilot study to assess the degree to which this may occur. Samples taken from the wells around the pilot study CDF immediately after the site was filled and nine months later were analyzed for PCBs and metals. The results do not indicate any movement of contaminants from the site. USACE also conducted various leachate testing events to estimate the quantity and quality of water that seeps through the CDF dikes at the New Bedford Harbor site after filling has been completed. These tests included batch testing and permeameter testing, both followed by chemical analysis to evaluate desorption isotherms.

Batch testing was performed to determine which conditions were necessary to achieve equilibrium or steady-state conditions between sediment and water. This testing included shaking time, sediment-water ratios, and sequential batch testing to determine desorption isotherms. Each test involved shaking a mixture of sediment and water for a prescribed length of time and then analyzing the sediment and extracted water.

Permeameter testing differed in that no agitation between the sediment and water occurred. Water was forced through a column of sediment under nitrogen pressure (an inert driving medium) to simulate leaching through a CDF. Again, the resulting sediment and water extract were analyzed for chemical constituents.

Results of the batch leachate testing exhibited negative desorption isotherms, indicating that concentrations should increase with time. Such a phenomenon could not continue indefinitely because of mass limits of contaminants available for release. Concentrations of PCBs from the permeameter were much lower than those from the batch tests. The peak total PCB concentrations observed in permeameter leachate were 18 ug/L in anaerobic sediment and 17.5 ug/L in aerobic sediment (Myers and Brannon, 1988).

If results from the pilot study indicate that the leachate concentrations are unacceptable, use of liners in construction of the CDFs should be reevaluated. Subsection 5.3.3 discusses the benefits and disadvantages of lining the CDFs.

Dike collapse, followed by erosion of the disposed sediments, would be unlikely to occur, even during storm events. The Hurricane Barrier is a good example of a stable embankment at New Bedford Harbor, and the locations identified for the shoreline disposal facilities would be in a less active environment.

No serious problems with the water treatment plant operation are anticipated. If the effluent exceeds the water quality criteria assigned, a simple process of halting system operations at that time and then restoring it to the designed output specifications would be necessary. This problem would be readily detected because there would be ongoing monitoring for PCBs and metals in the effluent stream. However, shutdown of the water treatment plant may require that the dredging operations are stopped to avoid overloading the treatment system.

Monitoring Considerations. Environmental monitoring of the dredging operation would include monitoring of suspended solids around the dredging operation. Monitoring stations would also be established at predetermined locations within the estuary and the lower harbor/bay to assess the degree of sediment/contaminant migration associated with dredging.

Monitoring of the hydraulic pipeline would include at least one crew of workmen in small shallow-draft boats. The crews would be in radio contact with the dredge operator so that appropriate action can be taken in the event of a leak or break in the line. Additional workmen would be required to monitor the operation of the booster pumps, as necessary.

Monitoring of operations associated with the dewatering, handling, and transportation of contaminated sediment would need to be implemented for protection of workers and the public. Ongoing sampling of water discharged from the water treatment facility would be necessary to ensure that system performance standards are met.

Monitoring systems for the disposal facilities would consist of monitoring wells placed to determine the presence of leachate and potential contaminants within leachate. This migration pathway may be difficult to monitor, due to the low levels of PCBs anticipated. To offset this uncertainty, USACE conducted bench-scale tests of the sediment to ascertain the leaching ability of the material. Results from these tests indicate that peak PCB concentrations on the elution curves in anaerobic and aerobic sediment were 0.018 and 0.0175 mg/L, respectively (Myers and Brannon, 1988).

Air monitoring would also be conducted to determine volatile emissions generated during the dredging and disposal operations. Long-term monitoring of biota, water, and sediment in the harbor would be necessary to assess the effectiveness of the remedial alternative. The monitoring programs for both the estuary and the lower harbor/bay would include 25 samples each of sediment, water, and biota four times per year for 30 years. In addition, every five years the sites would be reviewed for attainment with current regulations, requirements, and advisories.

7.4.5.2 Administrative Feasibility

Coordination among the lead agency (i.e., USACE or EPA), the City of New Bedford, and the Commonwealth of Massachusetts will be important. Coordination would involve active communication, including formal and informal meetings, among these agencies at critical points in the remedial action process. Because all activities would be conducted on-site, no permits are needed for these alternatives.

Coordination would also be required between the lead agencies and the Harbor Master to assure minimal interference with the fishing industry during dredging activities. Furthermore, coordination with the Harbor Master is also necessary to assure compatible land use when siting CDFs and treatment operations. Significant adverse administrative response is not anticipated for this alternative. However, because the dredged material would not be treated, this issue may be one of contention.

7.4.5.3 Availability of Services and Materials

Remediation is anticipated to be conducted by one prime contractor. Numerous companies capable of providing such services are available. Cutterhead dredges are readily available. A maximum of 90 days is anticipated for delivery and setup once ordered. Personnel trained in the use of health and safety equipment are also available to operate the machinery.

Contractors and equipment for the construction of the dewatering and water treatment plant, as well as the shoreline disposal facilities, are also available to respond to requests for proposals in a timely and competitive manner.

7.4.6 Cost

Tables 7-7 and 7-8 present the capital and O&M costs for Alternatives EST-3 and LHB-3. Separate cost components of this alternative include dredging, water treatment, material transport, and disposal into shoreline CDFs. Separate cost analyses were undertaken for Alternatives EST-3d and LHB-3d (which include mechanical dewatering) and are presented with the Alternative EST-3 and LHB-3 costs.

Figures 7-23 through 7-26 illustrate cost breakdowns for each of the four alternatives, including the variations using mechanical dewatering.

The dredging component includes all anticipated costs dealing with removing sediments from the estuary or the lower harbor/bay. Items include plant ownership costs, operating costs, piping and pumping the materials, and mobilization/demobilization and shutdown. The cost analysis also considered hazard protection equipment and monitoring. Other miscellaneous items included in the total cost are overhead, bond, and profit. The total cost was then broken down to \$9.66/cy in situ, based on a maximum pay yardage of 666,000 cy (USACE, 1988).

TABLE 7–7
COST ESTIMATE: ALTERNATIVES EST–3 AND 3d
DREDGE/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	COST EST–3	COST EST–3d
I. DIRECT COST		
A. Dredging	$5,098,000	$5,098,000
B. Dewater/Water Treatment	$7,488,000	$35,973,000
C. Material Hauling	$648,000	$7,134,000
D. CDF Construction	$38,952,000	$10,396,000
DIRECT COSTS	$52,186,000	$58,601,000
II. INDIRECT COST		
A. Health & Safety (@ 5%) Level D Protection [Activities: B,C]	$407,000	$2,155,000
B. Legal, Administration, Permitting (@ 6%)	$3,131,000	$3,516,000
C. Engineering (@ 10%)	$5,219,000	$5,860,000
D. Services During Construction (@ 10%)	$5,219,000	$5,860,000
E. Turnkey Contractor Fee (@ 15%)	$7,828,000	$8,790,000
INDIRECT COSTS	$21,804,000	$26,181,000
SUBTOTAL COSTS	$73,990,000	$84,782,000
CONTINGENCY (@ 20%)	$14,798,000	$16,956,000
TOTAL CAPITAL COSTS	$88,788,000	$101,738,000
PRESENT WORTH COSTS – 1989 (@ 5% for 8 years)	$71,732,000	$82,194,000
OPERATION AND MAINTENANCE COSTS (CDFs) (present worth @ 5% for 30 years upon completion)	$2,326,000	$670,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000	$3,376,000
TOTAL COSTS – ALTERNATIVE EST–3	$77,434,000	$86,240,000

TABLE 7-8
COST ESTIMATE: ALTERNATIVE LHB-3
DREDGE/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	COST LHB-3	COST LHB-3d
I. DIRECT COST		
A. Dredging	$3,846,000	$3,846,000
B. Dewater/Water Treatment	$6,543,000	$28,346,000
C. Material Hauling	$862,000	$1,883,000
D. CDF Construction	$34,661,000	$16,034,000
DIRECT COSTS	$45,912,000	$50,109,000
II. INDIRECT COST		
A. Health & Safety (@ 5%) Level D Protection [Activities: B,C]	$370,000	$1,511,000
B. Legal, Administration, Permitting (@ 6%)	$2,755,000	$3,007,000
C. Engineering (@ 10%)	$4,591,000	$5,011,000
D. Services During Construction (@ 10%)	$4,591,000	$5,011,000
E. Turnkey Contractor Fee (@ 15%)	$6,887,000	$7,516,000
INDIRECT COSTS	$19,194,000	$22,056,000
SUBTOTAL COSTS	$65,106,000	$72,165,000
CONTINGENCY (@ 20%)	$13,021,000	$14,433,000
TOTAL CAPITAL COSTS	$78,127,000	$86,598,000
PRESENT WORTH COSTS – 1989 (@ 5% for 6 years)	$66,091,000	$73,257,000
OPERATION AND MAINTENANCE COSTS (CDFs) (present worth @ 5% for 30 years upon completion)	$2,299,000	$1,178,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000	$3,376,000
TOTAL COSTS – ALTERNATIVE LHB-3	$71,766,000	$77,811,000

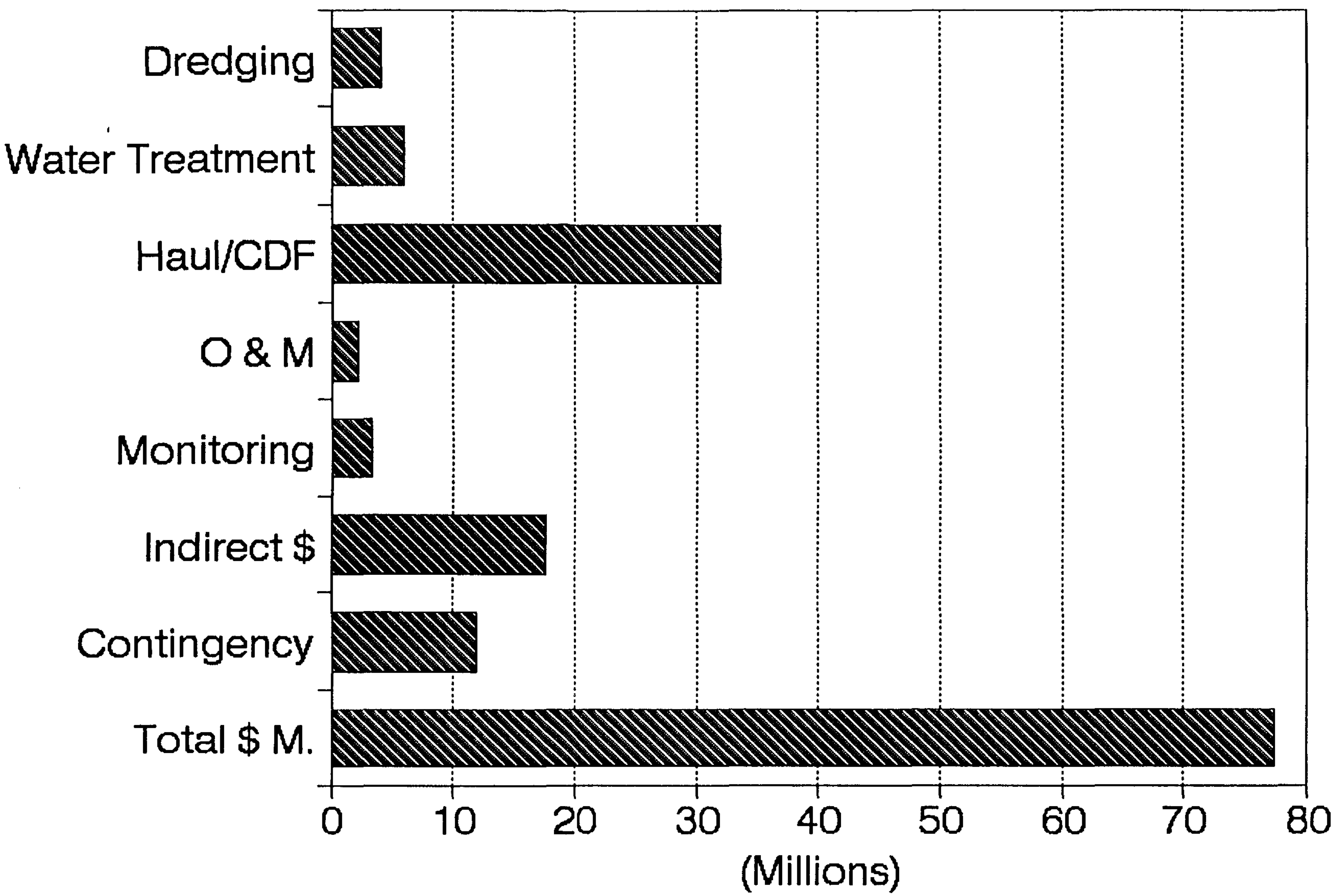

Figure 7-23

Cost Breakdown EST-3
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

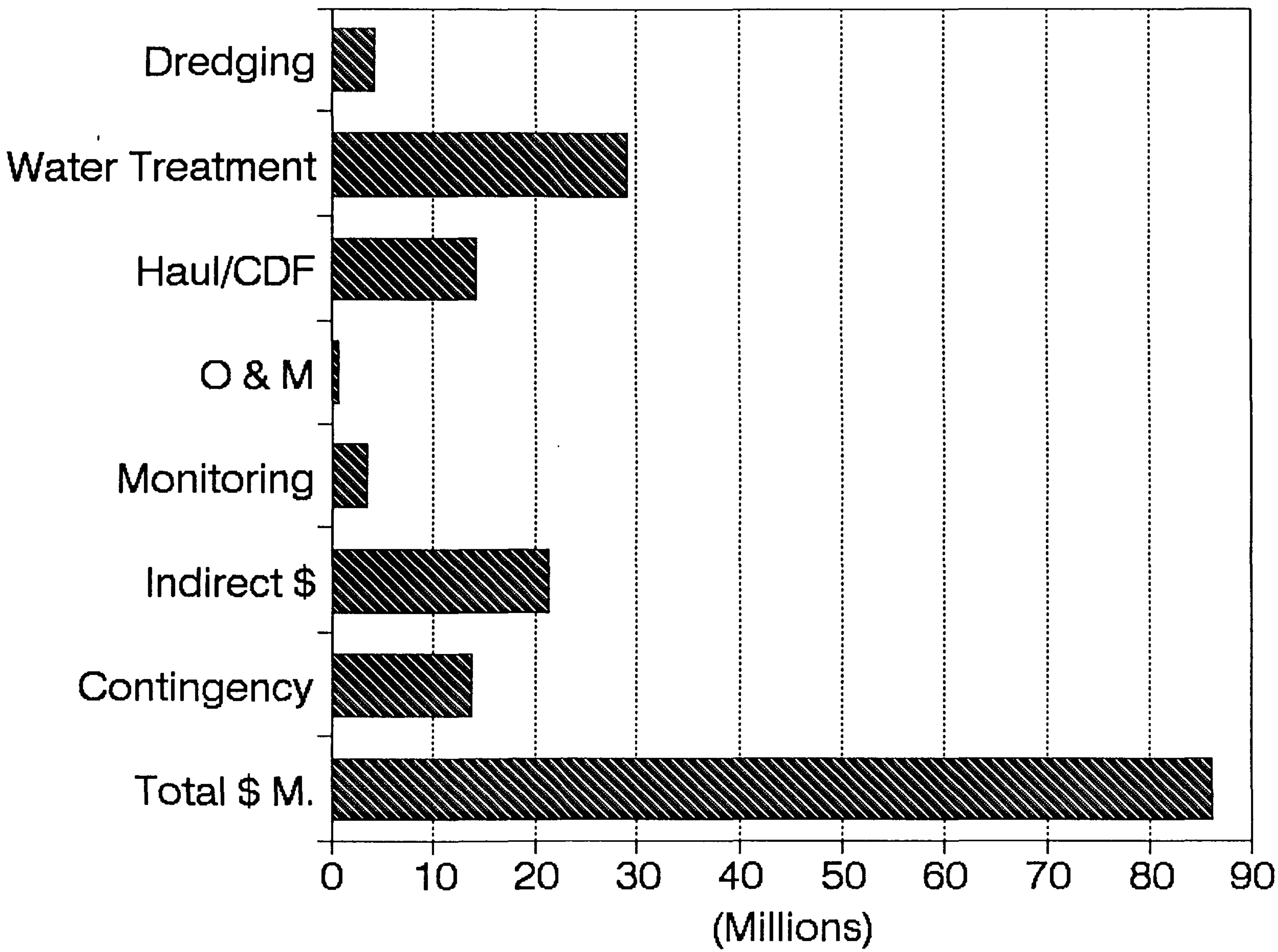

Figure 7-24

Cost Breakdown EST-3d
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

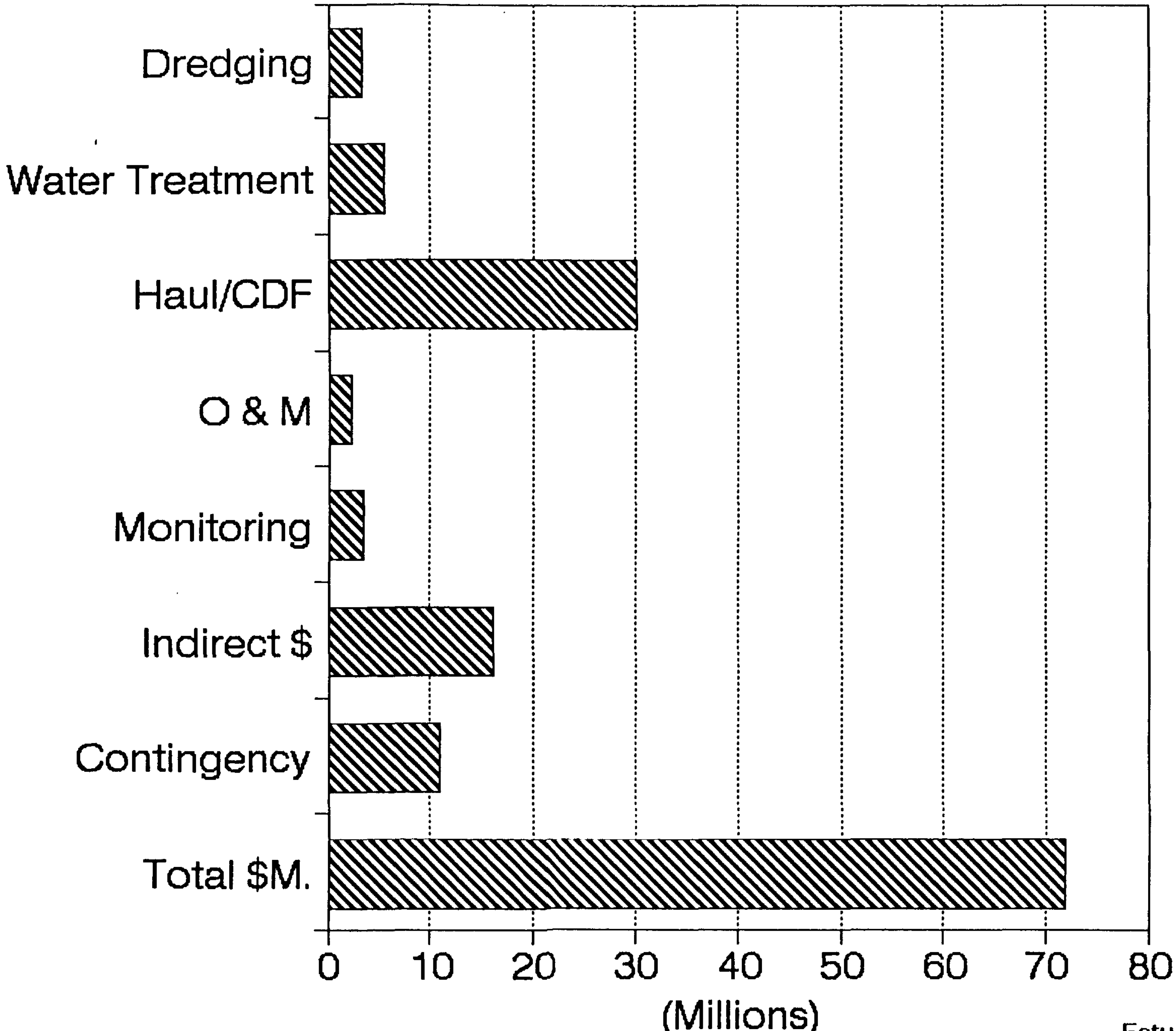

Figure 7-25

Cost Breakdown LHB-3
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

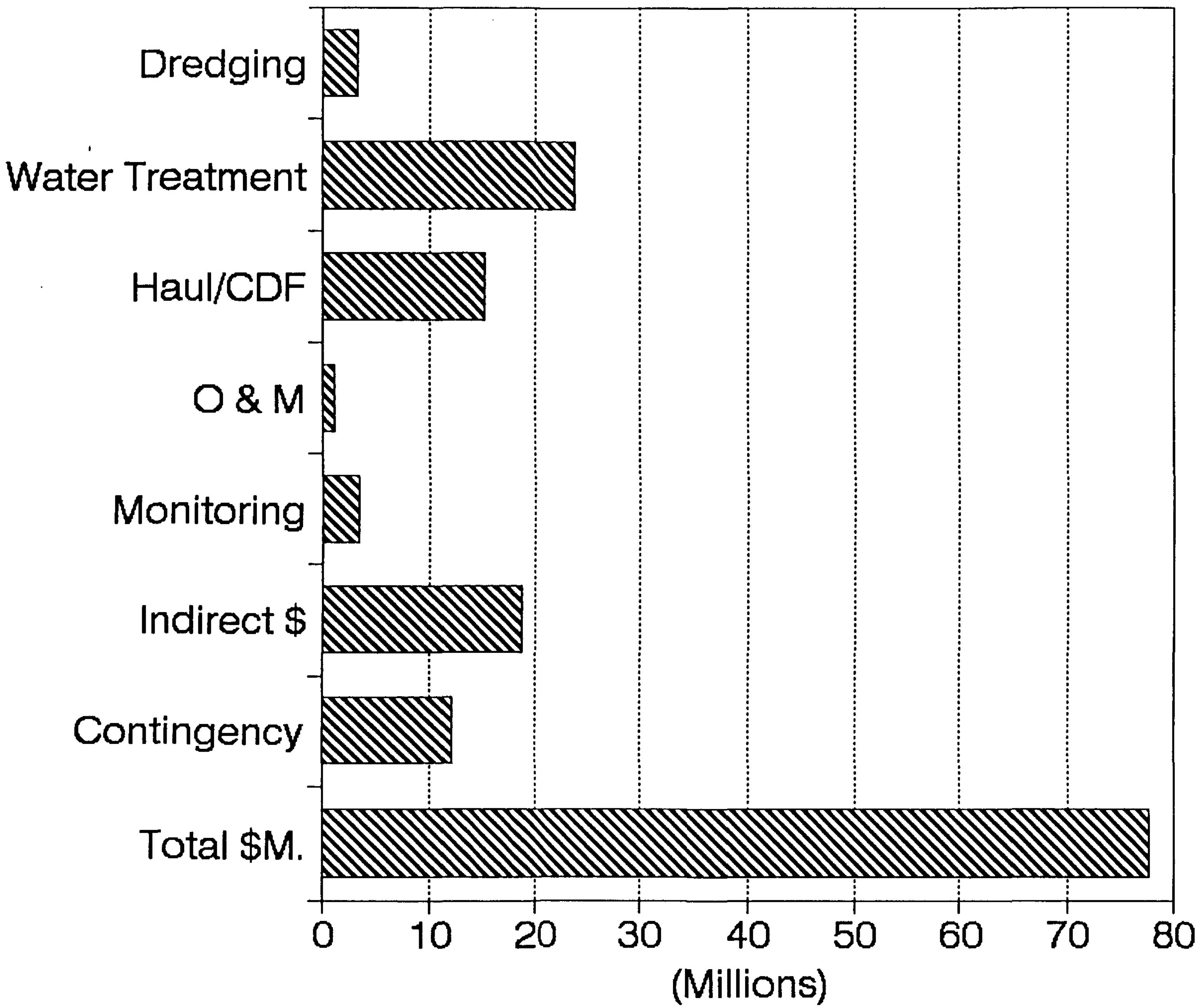

Figure 7-26

Cost Breakdown LHB-3d
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

Water treatment costs for this alternative involve treating the supernatant prior to discharge back to the harbor waters. The various equipment necessary to perform this function include a water holding tank and screening system, a coagulation/flocculation unit, a reactor/clarifier, and dual-media and carbon adsorption filtration units. The costs also include incineration of the spent carbon, as well as a building to house this equipment. Costs for the water treatment facility include O&M for the length of time necessary to remediate the given TCL. This facility has been designed to accommodate 1.5 million gallons per day (gpd), although currently only 911,000 gallons are anticpated to be treated daily.

Costs for Alternatives EST-3d and LHB-3d are based on the dredge pumping the slurry to a solids holding tank. Additional costs include a clarifier/thickener and plate and frame secondary dewatering units.

Material transport costs for this alternative involve the costs for pumping the effluent to the treatment plant from the various CDFs. Costs for Alternatives EST-3d and LHB-3d include trucking the dewatered sediment to the respective CDFs. Distances from the dewatering facility to the various CDF locations have been considered, as well as the time required to complete each trip. Where appropriate, transport costs also include depositing the dewatered sediment to the CAD cell sites.

The last capital cost component for this alternative is the construction of the CDF site(s). The costs for CDF construction were derived from past CDF construction experience in similar conditions and costs that were incurred for the construction of the pilot study CDF. Included in these costs are material and labor for the dike fill, geotextile and stone protection, capping for the site, and topsoil and seed. Costs also include silt curtains during construction, fencing, and traffic control. Health and safety factors were included in the various items where required. CDFs anticipated to be used for EST-3 are Sites 1, 1a, 3, 7, 4, and 8, Island 1, and the CAD cells. Utilizing mechanical dewatering would reduce the CDFs to Sites 1 and 4, and the CAD cell. For the lower harbor/bay, Sites 10 and 10a and Island 2 are anticipated to be used. Alternative LHB-3d would use only Sites 10 and 10a.

Health and safety costs, where not included as part of a line item within a given component (e.g., dredging), were added as other direct costs. For this alternative, costs for Level D health and safety protective equipment were added to the water treatment and material transport components at 5 percent of the overall cost of that item. For most activities, this is considered appropriate because no contact with contaminated material is anticipated. However, some specific operations (e.g., clearing debris from dredgehead) would require Level C protection.

Other costs were also considered for the total cost of implementing this alternative. Legal, administrative, and permitting costs are anticipated to add an additional 6 percent of the total capital and O&M costs.

Engineering and services during remediation are anticipated to cost an additional 10 percent each. Fees for the prime contractor administering the remediation are an additional 15 percent. Finally, a 20 percent contingency has been added to the subtotal of these items to derive the final cost for each alternative.

If it is determined that the PCB-contaminated sediment in the wetlands will need to be removed and new wetland habitats created, an additional cost, estimated to be $10 million, would be incurred. This cost includes dredging 139,000 cy of sediment and planning, construction, and propagation of new wetland habitats along the eastern shoreline of the estuary. The cost does not include any additional costs associated with material handling, CDF construction, or dewatering and water treatment; however, the additional volume of sediment could significantly increase these costs.

A sensitivity analysis of the alternative components was conducted to determine which factors may significantly change overall costs. For these alternatives, the component that is the most costly and may have a high degree of uncertainty is construction of the CDFs. For the USACE pilot study in the estuary, the two bids received for CDF construction were 113 and 160 percent of the government estimate. To determine the change in total cost for these alternatives, the CDF costs were increased by 136 percent of the current total. (It was assumed that the low bid for the full-scale work would not exceed the average percent increase of the two bids received for the pilot study project.) The cost of Alternative EST-3 increased approximately 26 percent, from $77 million to $97 million, while Alternative EST-3d increased only about 6 percent, from $86 million to $91 million. For the lower harbor/bay alternatives, Alternative LHB-3 increased from $72 million to $90 million (25 percent), and Alternative LHB-3d increased 10 percent from $78 million to $86 million.

The CDF costs are based on the assumption that the CDFs would be constructed without a RCRA-type liner system. A sensitivity analysis was performed to show how the total cost would change if the CDFs were constructed with liners. Lining the CDFs chosen for Alternatives EST-3 and LHB-3 would increase the total costs by 32 percent to $102 million and $95 million, respectively. For Alternative EST-3d, the cost would increase by approximately 12 percent to $96 million, while the cost of Alternative LHB-3d would increase 14 percent to $89 million.

The alternatives that include mechanical dewatering as a cost component (i.e., Alternatives EST-3d and LHB-3d) are more sensitive to changes in water treatment costs. For this analysis, it was assumed that the dredge would pump a 2 percent solids slurry (instead of 3.9 percent). While the 1.5-million gallons-per-day treatment plant would have adequate capacity to handle the excess water for the gravity dewatering scenarios (i.e., Alternatives EST-3 and LHB-3), the alternatives that use mechanical dewatering would require a larger plant. For this analysis, the capital and O&M costs of the larger plant were estimated and the total cost computed using these new values. Changing the influent slurry solids concentration would also affect the costs of CDF construction and material hauling; however, for the purpose of this analysis, these costs were held constant to isolate the sensitivity of the overall cost to an increase in water treatment costs. Increasing the water treatment cost by 9 percent increased the total cost of Alternative EST-3d to $91 million (a 6 percent rise). The total cost of Alternative LHB-3d increased 5 percent to $82 million due to a 10 percent increase in the cost of water treatment. Tables 7-9 through 7-12 illustrate the effects of these changes.

7.4.7 Compliance with ARARs

Alternatives EST-3 and LHB-3, dredging and on-site disposal of contaminated sediments, are designed to meet the 10-ppm PCB TCL for sediments, as discussed in Sections 3.0 and 4.0. Chemical-specific ARARs are presented in Subsection 4.2.2.1. Alternatives EST-3 and LHB-3 will not attain chemical-specific ARARs through remediation of contaminated sediments to 10 ppm PCBs, as previously discussed in Subsection 7.3.7.

Implementation of the dewatering option would mean the Massachusetts Surface Water Quality Standards (310 CMR 4.00) would apply to the supernatant that will be generated when dewatering the dredged sediments. This regulation sets standards for maximum levels of contaminants that can be discharged to the surface waters of the state.

National Air Quality Standards (40 CFR 40) and Massachusetts Air Pollution and Air Quality Regulations (310 CMR 6.00-8.00) would apply to this alternative because no remedial action should cause a negative impact on existing air quality. Monitoring systems can be engineered into the implementation of this alternative to gauge whether dredging and disposal of the sediments cause volatilization of any contaminants. Any impacts detected would be prevented or minimized by best available engineering controls during dredging and disposal activities.

TABLE 7-9
SENSITIVITY ANALYSIS: ALTERNATIVE EST-3
DREDGE/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)	COST (2)
DIRECT COSTS			
A. Dredging	$5,098,000	$5,098,000	$5,098,000
B. Dewater/Water Treatment	$7,488,000	$7,488,000	$7,488,000
C. Material Hauling	$648,000	$648,000	$648,000
D. CDF Construction	$38,952,000	$57,249,000	$52,974,000
TOTAL DIRECT COSTS	$52,186,000	$70,483,000	$66,208,000
TOTAL INDIRECT COSTS	$21,804,000	$29,304,000	$27,552,000
CONTINGENCY	$14,798,000	$19,957,000	$18,752,000
TOTAL CAPITAL COSTS (present worth)	$71,732,000	$96,741,000	$90,899,000
O&M/MONITORING (present worth)	$5,702,000	$5,702,000	$5,702,000
TOTAL COST (present worth)	$77,434,000	$102,443,000	$96,601,000

1. CDF costs include liner
2. CDF bid amount 36% greater than design estimate

TABLE 7-10
SENSITIVITY ANALYSIS: ALTERNATIVE EST-3d
DREDGE/DEWATER/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)	COST (2)	COST (3)
DIRECT COSTS				
A. Dredging	$5,098,000	$5,098,000	$5,098,000	$5,098,000
B. Dewater/Water Treatment	$35,973,000	$35,973,000	$35,973,000	$39,340,000
C. Material Hauling	$7,134,000	$7,134,000	$7,134,000	$7,134,000
D. CDF Construction	$10,396,000	$17,584,000	$14,139,000	$10,396,000
TOTAL DIRECT COSTS	$58,601,000	$65,789,000	$62,344,000	$61,968,000
TOTAL INDIRECT COSTS	$26,181,000	$29,128,000	$27,716,000	$27,731,000
CONTINGENCY	$16,956,000	$18,983,000	$18,012,000	$17,940,000
TOTAL CAPITAL COSTS (present worth)	$82,194,000	$92,020,000	$87,312,000	$86,962,000
O&M/MONITORING (present worth)	$4,046,000	$4,046,000	$4,046,000	$4,046,000
TOTAL COST (present worth)	$86,240,000	$96,066,000	$91,358,000	$91,008,000

1. CDF costs include liner
2. CDF bid amount 36% greater than design estimate
3. Increase water treatment plant capacity to handle water from 2% solids dredge slurry (item B only)

TABLE 7-11
SENSITIVITY ANALYSIS: ALTERNATIVE LHB-3
DREDGE/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)	COST (2)
DIRECT COSTS			
A. Dredging	$3,846,000	$3,846,000	$3,846,000
B. Dewater/Water Treatment	$6,543,000	$6,543,000	$6,543,000
C. Material Hauling	$862,000	$862,000	$862,000
D. CDF Construction	$34,661,000	$50,929,000	$47,139,000
TOTAL DIRECT COSTS	$45,912,000	$62,180,000	$58,390,000
TOTAL INDIRECT COSTS	$19,194,000	$25,864,000	$24,310,000
CONTINGENCY	$13,021,000	$17,609,000	$16,540,000
TOTAL CAPITAL COSTS (present worth)	$66,091,000	$89,377,000	$83,952,000
O&M/MONITORING (present worth)	$5,675,000	$5,675,000	$5,675,000
TOTAL COST (present worth)	$71,766,000	$95,052,000	$89,627,000

1. CDF costs include liner
2. CDF bid amount 36% greater than design estimate

TABLE 7-12
SENSITIVITY ANALYSIS: ALTERNATIVE LHB-3d
DREDGE/DEWATER/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)	COST (2)	COST (3)
DIRECT COSTS				
A. Dredging	$3,846,000	$3,846,000	$3,846,000	$3,846,000
B. Dewater/Water Treatment	$28,346,000	$28,346,000	$28,346,000	$31,219,000
C. Material Hauling	$1,883,000	$1,883,000	$1,883,000	$1,883,000
D. CDF Construction	$16,034,000	$24,177,000	$21,806,000	$16,034,000
TOTAL DIRECT COSTS	$50,109,000	$58,252,000	$55,881,000	$52,982,000
TOTAL INDIRECT COSTS	$22,056,000	$25,394,000	$24,422,000	$23,377,000
CONTINGENCY	$14,433,000	$16,729,000	$16,061,000	$15,272,000
TOTAL CAPITAL COSTS (present worth)	$73,257,000	$84,912,000	$81,519,000	$77,515,000
O&M/MONITORING (present worth)	$4,554,000	$4,554,000	$4,554,000	$4,554,000
TOTAL COST (present worth)	$77,811,000	$89,466,000	$86,073,000	$82,069,000

1. CDF costs include liner
2. CDF bid amount 36% greater than design estimate
3. Increase water treatment plant capacity to handle water from 2% solids dredge slurry (item B only)

Dredging sediment would trigger federal and state location-specific ARARs for wetlands and floodplains. These ARARs are described in Subsection 7.3.7 and summarized in Subsection 4.2.2.2. Substantive requirements of Section 404 of the CWA and the USACE regulations at 40 CFR 230 must be followed. To meet the PCB TCL of 10 ppm, approximately 43 acres of Acushnet River Estuary wetlands would have to be excavated and removed to the CDFs. Pursuant to Section 404 (b)(1) of the CWA guidelines (promulgated as regulations in 40 CFR 230.10), degradation or destruction of aquatic sites should be avoided to the extent possible. Under Section 404 (b)(1) of the CWA, no discharge of dredged or fill material will be permitted if there is a practicable alternative to the proposed discharge that would have less adverse impact on the aquatic ecosystem, providing the alternative does not have other significant adverse environmental consequences. If there is no practicable alternative, adverse impacts to the aquatic ecosystem/wetland should be minimized according to 40 CFR 230.10(d).

If a functioning wetland with environmental value is negatively affected from a remedial action, mitigation techniques such as wetland restoration, enhancement, or creation may be appropriate. Executive Orders 11988 and 11990 (see Subsection 4.2.2.2), which are implemented through NEPA (40 CFR Part 6, Appendix A), are ARARs that may also require wetlands and floodplain mitigation. If excavation of the wetlands is required, then restoration of wetlands would occur as part of the construction of this alternative. Reclamation of wetlands damaged or destroyed is included as an option to Alternatives EST-3 and LHB-3, and subsequent alternatives that potentially require dredging and excavation of estuary wetlands.

Coordination with the U.S. Fish and Wildlife Service would occur during remedial alternative development, evaluation, and selection phases to ensure compliance with substantive requirements of the U.S. Fish and Wildlife Coordination Act.

On the state level, water quality certification, waterway procedures, and the wetlands protection regulations apply. Compliance with substantive requirements would be met.

The CDFs are designed to be constructed on the bank of the Acushnet River and shoreline of the harbor. This design places the units partially on land and partially in water. Under the TSCA standards (40 CFR 761.75), chemical waste disposal facilities located within the 100-year floodplain would be designed, constructed, and operated to prevent washouts by the 100-year flood. CDF construction would meet these standards.

Several action-specific ARARs would go into effect during various phases of implementation of this alternative. Under the CWA (40 CFR 231) and Massachusetts Certification for Dredged

Material Disposal and Filling in Waters (310 CMR 9.00), dredging and transport of contaminated sediments to shore-based facilities would have to meet technology requirements set forth in these regulations. Dredging techniques are determined by the characteristics of sediments and material to be dredged. This material would be transported to shore using best engineering practices.

The administration of waterways licenses sets requirements to prevent interference with commercial and recreational navigation, and the protection of special or sensitive marine and coastal areas. These requirements can be met through engineered controls implemented during construction. Dredging activities would be timed and coordinated to minimize interference with shipping and boating traffic, and a monitoring program would be implemented during dredging to detect and minimize the spread of contaminated sediments.

ARARs that pertain to the dewatering option of this alternative relate to either the O&M of wastewater treatment facilities (314 CMR 12.00) or treatment standards for process waters. Pilot test results indicate that treatment of the supernatant water generated during dewatering would meet promulgated treatment standards. Construction and operation procedures and standards would be attained through inclusion in the design and implementation of the alternative.

TSCA regulations (40 CFR 761) regulate the disposal of dredged materials contaminated with PCBs in concentrations of 50 ppm or more. This material must be incinerated to meet the performance requirements of 40 CFR 761.70, or a chemical waste landfill in compliance with the technical requirements of 40 CFR 761.75. Alternative remedial actions may be approved by EPA if technical, environmental, and economic considerations indicate disposal in a federally permitted incinerator or chemical waste landfill is not reasonable or appropriate. Alternative disposal methods must provide adequate protection to public health and the environment.

Massachusetts Hazardous Waste Regulations (310 CMR 30.00) are relevant and appropriate to the design, construction, and O&M of the CDFs. These requirements are similar to standards set forth under RCRA; however, the state regulations are more stringent in the area of liners. To comply with 310 CMR 30.00, the CDFs would need to achieve a maximum permeability standard of 1×10^{-7} cm/sec. State regulations indicate that to achieve this standard, landfills must have a double liner with a leak detection and leachate collection system. The alternative option that includes installation of a liner in the CDFs will attain this ARAR. Construction of CDFs without liners will have to demonstrate compliance with the permeability standard.

Massachusetts Hazardous Waste Regulations also govern the closure and post-closure care of the CDFs. Closure requirements (310 CMR 30.580) state that a final cover must be designed and constructed to prevent migration of liquids, have minimal maintenance requirements, promote drainage, minimize erosion, and accommodate settling. The cover integrity should be maintained throughout the post-closure care period. The proposed containment system meets these requirements to the extent applicable and would be periodically monitored to assure its effectiveness.

All site activities, including monitoring, will be carried out pursuant to OSHA standards (29 CFR 1904, 1926) and Massachusetts Right-to-Know regulations (see Subsection 4.2.2.3).

7.4.8 <u>Overall Protection of Public Health and the Environment</u>

Reduction of shoreline sediment PCB concentrations to 10 ppm will provide an adequate level of protection to public health and a significant reduction in ecological risks over baseline conditions. The 10-ppm TCL was derived based on protecting young children (through age 6) from direct contact and incidental ingestion exposure to sediments. Because children were considered the most sensitive population, the risks associated with contaminant exposure by older children and adults will be lower than 10^{-5}.

The reduction in sediment PCB concentrations will result in a decrease in surface water and biota concentrations after an appropriate lag period. Model projections indicate that PCB concentrations in surface water and biota will approach the chronic AWQC and FDA tolerance level, respectively.

A 10-ppm residual sediment concentration will result in significant reduction in ecological risks. This reduction comes primarily from the decrease in the exposure concentrations in sediment and surface water.

Removal actions (e.g., dredging) are expected to have adverse environmental impacts. The integrity of the benthic community will be destroyed as sediments are dredged. The time required to recolonize this community and stabilize the ecosystem is not known.

7.5 ALTERNATIVES EST-4 AND LHB-4: REMOVAL, SOLIDIFICATION, AND ON-SITE DISPOSAL

7.5.1 <u>General Description</u>

Alternatives EST-4 and LHB-4 would consist of dredging the estuary and lower harbor/bay sediment, dewatering the sediment and treating all process wastewaters produced during dewatering, and solidifying the dewatered sediment on-site to immobilize PCBs and heavy metals (Figure 7-27). The solidified material would be disposed of on-site in CDFs 1 and 3 and the estuary CAD cells for the estuary, and in CDFs 10, 10a, and 4 for the harbor clean-up. Figure 7-28 is a process flow diagram of Alternatives EST-4 and LHB-4.

The volume of sediment requiring treatment was estimated to be 528,000 cy for the estuary and 398,000 cy for the lower harbor/bay. The total volume of solidified material that would require disposal is approximately 1,195,000 cy. Treatment of the sediment would likely take place on Marsh Island or in the Conrail Railyard (Figure 7-29).

The following paragraphs outline the components of Alternatives EST-4 and LHB-4. Complete descriptions of the components discussed previously are in the subsections noted.

<u>Dredging</u>. Dredging of the sediment and transport to the CDF would be conducted as described in Subsection 7.4.1.

<u>Dewatering</u>. Primary and secondary dewatering of the sediment would be conducted as described in Subsection 7.4.1.

<u>Water Treatment</u>. Treatment of CDF effluent and dewatering filtrate would be conducted as described in Subsection 7.4.1.

<u>Solidification</u>. S/S of waste material is a well-established technology that has been used for approximately 20 years. Hazardous waste applications typically involve blending contaminated material with an inorganic cementitious additive (e.g., Portland cement, kiln dust, fly ash, or lime) to facilitate encapsulation of the hazardous constituents. Encapsulation results from a pozzolanic reaction (i.e., aluminous and siliceous compounds that harden in the presence of lime), whereby the cementitious additive forms crystalline calcium silicate hydrates, calcium aluminate hydrates, and calcium aluminosilicate hydrates. These interlocking compounds surround contaminants and, after curing, form structurally stable, less permeable matrices that inhibit contaminant mobility.

Bench-scale studies of S/S conducted by USACE indicated that cement-based formulations used as solidifying agents were effective in producing hardened material that significantly reduces the mobility of PCBs and metals. USACE investigated S/S products of three technologies: Portland cement, Portland cement with Firmix proprietary additive, and STC proprietary additive. Formulations for these tests were all on the order of a few tenths of a part of the additives to one part of wet

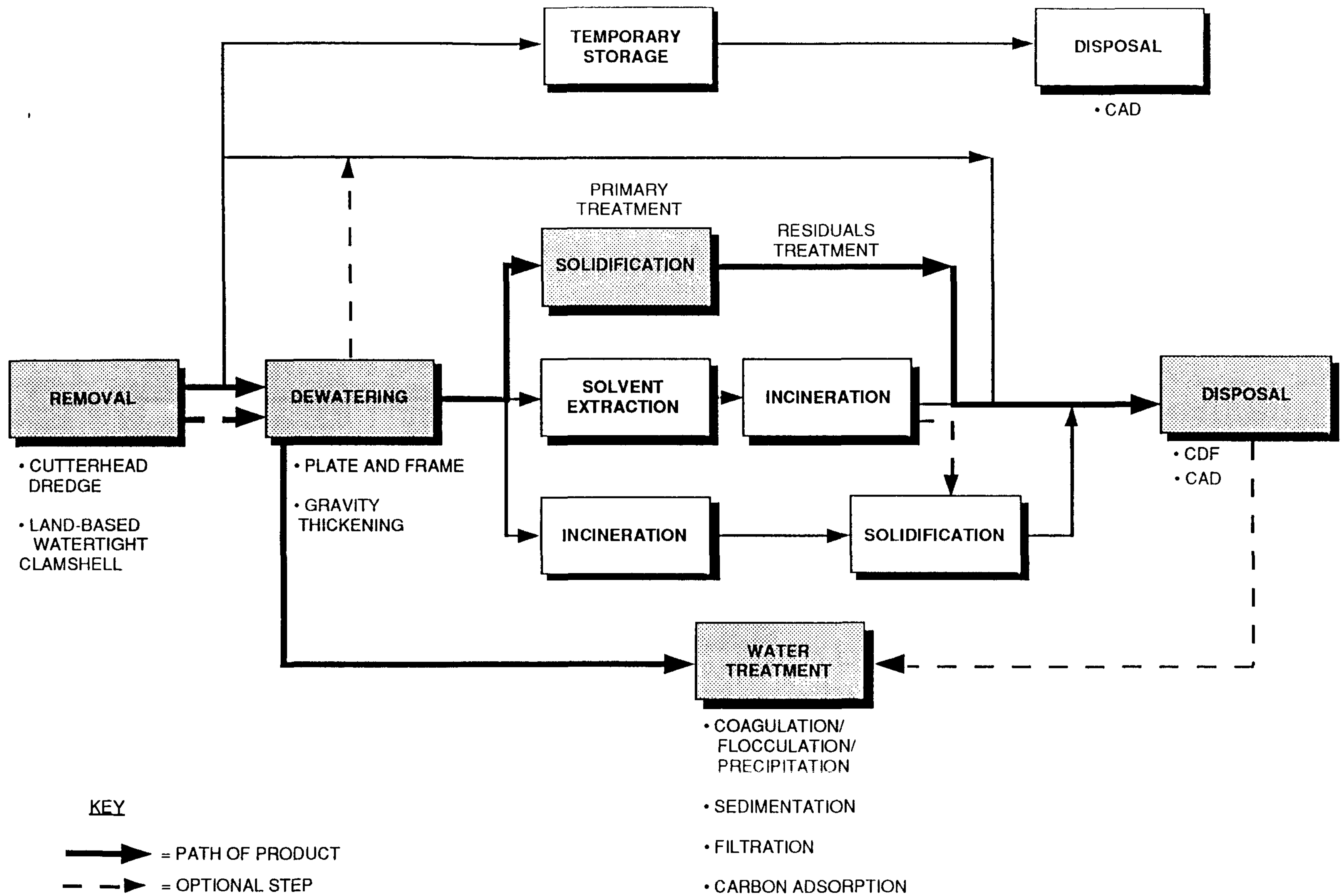

FIGURE 7-27
EST-4 AND LHB-4 DREDGE / SOLIDIFY / DISPOSE
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

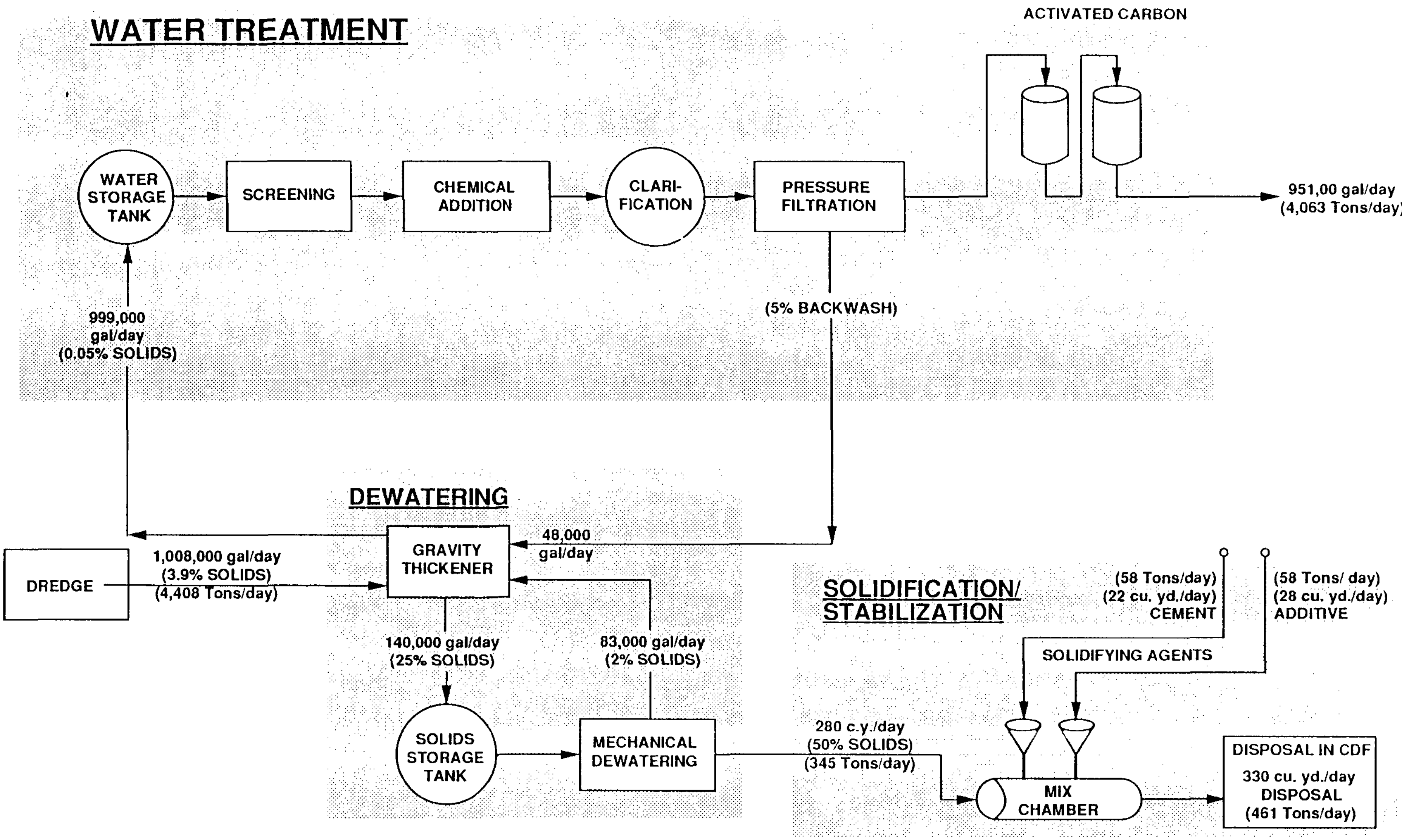

FIGURE 7-28
ALTERNATIVES EST-4 AND LHB-4
MASS BALANCE
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

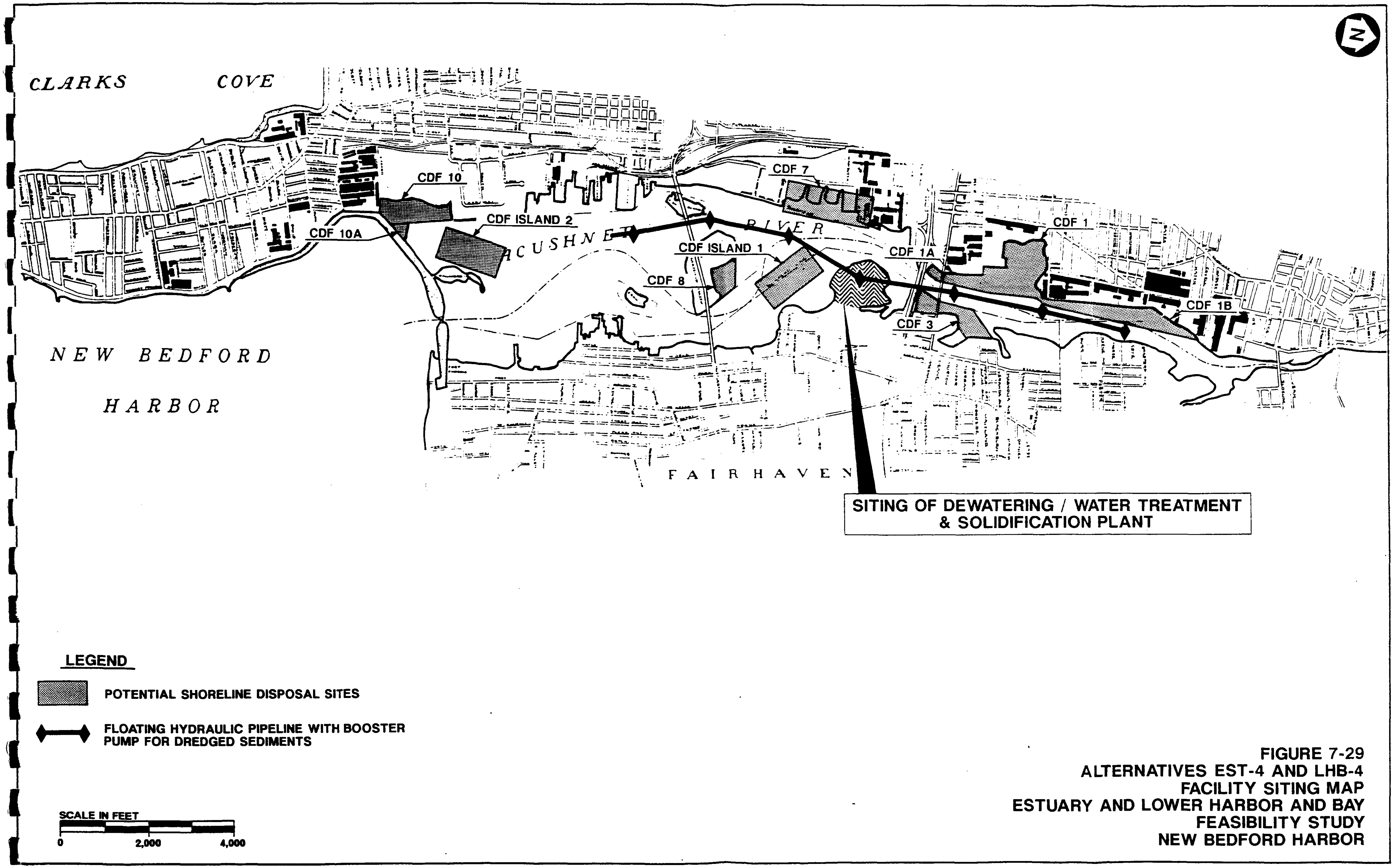

FIGURE 7-29
ALTERNATIVES EST-4 AND LHB-4
FACILITY SITING MAP
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

sediment. USACE tested these S/S formulations on estua composite and Hot Spot Area sediment samples.

Results of the USACE work indicated that the three S/S process can physically stabilize New Bedford Harbor sediment. All t formulations except one (i.e., Portland cement/wet sedime formulation) exceeded the minimum 50 psi UCS criteri established by EPA OSWER (Myers and Zappi, 1989). The highe 28-day UCS for any of the S/S processes was 481 psi for the S process. Solidified/stabilized New Bedford Harbor sediment h strengths above the range normally associated with hard cla (28 to 56 psi) and solidified industrial sludge (8 to 43 psi but lower than the range normally associated with low-streng concrete (Myers and Zappi, 1989).

Although release of PCBs from processed sediment was reduced one or two orders of magnitude as measured by the chemic leaching test, complete chemical stabilization of PCBs a metals was not achieved for the three S/S process formulatio tested by USACE. Batch leaching tests performed ground-solidified sediment samples using distilled deioniz water indicated that leaching of cadmium and zinc was eliminat from processed sediment, and that leaching of lead would reduced by two to three orders of magnitude. However, t amount of copper and nickel leached from the processed sedime was significantly higher for all three S/S processes than t amount leached from untreated sediment (Myers and Zappi, 1989

The three S/S processes tested by USACE are among nearly t dozen commercial processes available. Additional bench-testi would be necessary, prior to final selection of an S/S proces to identify the formulation that is most effective immobilizing PCBs and all heavy metals. This study would al identify the optimal water content to provide the greate economy while achieving both chemical and physica stabilization.

Solidification would be accomplished as a batch proces Dewatered sediment would be mixed with the solidifying additiv in an enclosed trailer-mounted mixing unit to ensure unifo mixing and to control potential air emissions of PCBs during t mixing process. Based on the USACE results and pendi additional testing, it is assumed that approximately 0.3 ton solidifying additive would be required for each ton of w sediment. Solidification equipment will be sized to process t dewatered sediment at the rate it is generated (i.e., no stora would be required). Following solidification, the was material would undergo EP Toxicity/TCLP analysis to ensure t process effectiveness.

Wetlands Remediation. Removal of wetlands sediment and t establishment of new wetland habitats would be conducted described in Subsection 7.4.1. Treatment and disposal of t additional 139,000 cy of sediment would be conducted described herein.

7.5.2 Short-term Effectiveness

Risk to the community (i.e., local residents) is expected to minimal during implementation of Alternatives EST-4 and LHI for the same reasons discussed in Alternatives EST-3 and LHE (see Subsection 7.4.3).

To minimize or prevent such exposure to workers on-site duri remedial activities, personal protection equipment (i.e respirators, overalls, and gloves) would be used. Potenti exposure to contaminants could occur by dermal contact a inhalation of airborne particulates or volatilized contaminant as a result of dredging operations (e.g., clearing debris fr or unclogging the dredgehead), dewatering the sediment, a handling the sediment during solidification operations. addition, air monitoring would be conducted to ensure work safety within immediate areas of remedial activity.

7.5.3 Long-term Effectiveness and Permanence

The long-term effectiveness of dredging sediment to remove PC was discussed in Alternatives EST-3 and LHB-3 (see Subsecti 7.4.3).

USACE tests of solidification of New Bedford Harbor sedime indicate that solidification can effectively immobilize PCBs a certain heavy metals. PCB leachability was reduced by facto of 10 to 100. The leachability of cadmium and zinc was al significantly reduced. Copper and nickel did exhibit increas mobility when treated with each of the three S/S formulation Additional bench- and/or pilot-scale testing would be requir to determine the optimum S/S formulation that would effective bind both the PCBs and all metals. However, the long-te permanence of solidification cannot be assessed because litt performance data exist to address this issue.

7.5.4 Reduction in Mobility, Toxicity, and Volume

Disposal of solidified sediment in CDFs is expected to redu the mobility of PCBs and metals. However, the long-te reduction in mobility cannot be assessed because physic integrity of the solidified sediment over time is unknow Solidification would increase the volume of the treated sedime by about 25 percent over the dewatered sediment.

7.5.5 Implementation

7.5.5.1 Technical Feasibility

Constructability. Few difficulties are expected to associated with construction and implementation of technologi within this alternative. Dredging is a well-develop operation, and few problems are anticipated with the hydraul transport of dredge material to the dewatering facility. T dewatering and water treatment technologies have been us extensively in the wastewater and water treatment industrie Equipment necessary to dewater dredged materials and tre PCB-contaminated filtrate has been bench-tested on New Bedfo Harbor sediment and is readily available. Further tests may necessary for process optimization prior to full-scale start (Wade, 1988).

Bench-scale tests performed by USACE on New Bedford Harb sediment determined that S/S processes are capable of reduci the leachability of PCBs and certain metals. Addition bench-scale tests are needed to identify solidifyin formulations that would immobilize copper and nickel.

Reliability. Hydraulic dredging with a cutterhead dredge ha been demonstrated to be a reliable technology for use in Ne Bedford Harbor. It is possible that delays will be encountere in the dredging operation due to inclement weather and downtim to remove debris along the shoreline areas if uncovered.

No delays are anticipated in the construction or operation o the dewatering and water treatment operations. Issue pertaining to acquisition of land for CDF construction ma create delays.

Bench-scale studies indicate that New Bedford Harbor sediment can be solidified/stabilized by various Portland cemen formulations. Furthermore, this technology has been use extensively in the nuclear industry to contain wastes and ha been demonstrated in similar harbor scenarios both in the U.S and Japan (Myers and Zappi, 1989).

Although bench-scale studies indicate favorable solidificatio results, several aspects of field application have not bee addressed. However, these items, including scale-up factors long-term stability, and engineering economy, are no anticipated to be significant issues for a well-demonstrate technology, such as S/S.

The long-term stability of the treated waste is relativel undocumented for PCBs and other organics. In the absence o long-term performance data, a program would have to b established to monitor any deterioration in the effectiveness the immobilization of these contaminants.

Support and Installation. The support requirements necess for the dredging, dewatering/water treatment, and C construction operations are discussed in Subsection 7.4.

Site preparation and set-up time for the solidification proc for full-scale operation is estimated to be six to eight wee The process train has been designed to maintain the dred output.

Ease of Undertaking Additional Remedial Action. The potenti problems associated with dredging, water treatment, and dispos that could require future remedial actions are discussed Subsection 7.4.5.

If the solidified material were to break down, anoth treatment, either in situ or after re-excavation from the CDF may be required. Therefore, the costs involved would inclu the new treatment and material moving and handling.

Air and water monitoring during the dredging operation would conducted as described in Subsection 7.4.5.

Appropriate monitoring of dewatering and solidificati operations would be necessary to provide protection to worke and the public. Periodic sampling of the water discharged fr the water treatment facility would be necessary to verify th system performance standards are met.

7.5.5.2 Administrative Feasibility

Coordination among the lead agency (i.e., USACE or EPA), t City of New Bedford, and the Commonwealth of Massachusetts wi be important. Coordination would involve active communicatio including formal and informal meetings, among these agencies critical points in the remedial action process. Because a activities will be conducted on-site, permits will not need be obtained for this alternative. Because the solidificati technology is understood by the general population, th alternative is not anticipated to create significant adver response.

7.5.5.3 Availability of Services and Materials

The availability of dredging equipment, dewatering/wat treatment, and CDF construction is discussed in Subsecti 7.4.5. Required equipment for solidification is readil available. The necessary materials are also general available, although the required quantities will result in t need for bulk delivery and on-site storage facilities. T areal requirement for the process plants and bulk storage approximately 1 acre. This area has not yet been procure although either the Marsh Island site in Fairhaven or t Conrail Railyard in New Bedford would be well-suited for th treatment process.

7.5.6 Cost

Tables 7-13 and 7-14 present the capital and O&M costs f Alternatives EST-4 and LHB-4. Separate cost components of th alternative include dredging, dewatering and water treatmen solidification of the dewatered sediments, material transpor and disposal into shoreline CDFs. Each component has be scaled to accommodate the daily dredge output of 280 cy in si (50 percent solids by weight).

Cost breakdowns for these alternatives are presented in Figur 7-30 and 7-31. The dredging, dewatering/water treatment, a CDF construction components are discussed in Subsection 7.4.5.

The costs for solidification include equipment and material necessary to solidify the sediment at a rate that can maintai the sediment output from the dredge working at 280 cy/day Costs include Portland cement and other additives necessary t achieve a predetermined strength.

Material transport costs for this alternative involve the cost for trucking the dewatered sediment to the respective CDFs Distances from the dewatering facility to the various CD locations have been considered, as well as time required t complete each trip. Where appropriate, transport costs als include depositing the dewatered sediment into the CAD sites.

Health and safety costs, where not included as part of a lin item within a given component (e.g., dredging), were added a other direct costs. For this alternative, Level D health an safety factors were added to the water treatment and materia transport components at 5 percent of the overall cost of tha item.

Other costs were also considered for the total cost o implementing this alternative. Legal, administrative, an permitting costs are anticipated to add an additional 5 percen of the total capital and O&M costs. Engineering and service during remediation are anticipated to cost an additional 10 an 5 percent, respectively. Finally, a 20 percent contingency wa added to the subtotal of these items to derive the final cos per alternative. The indirect costs and contingency are base on standard engineering practices using undeveloped desig conditions.

If it is determined that the PCB-contaminated sediment in th wetlands will need to be removed and new wetland habitat

TABLE 7-13
COST ESTIMATE: ALTERNATIVE EST-4
DREDGE/SOLIDIFY/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	COST
I. DIRECT COST	
A. Dredging	$5,098,000
B. Dewater/Water Treatment	$35,973,000
C. Sediment Treatment	$52,778,000
D. Material Hauling	$7,782,000
E. CDF Construction	$14,276,000
DIRECT COSTS	$115,907,000
II. INDIRECT COST	
A. Health & Safety (@ 5%) Level D Protection [Activities: B,D]	$2,188,000
B. Legal, Administration, Permitting (@ 6%)	$6,954,000
C. Engineering (@ 10%)	$11,591,000
D. Services During Construction (@ 10%)	$11,591,000
E. Turnkey Contractor Fee (@ 15%)	$17,386,000
INDIRECT COSTS	$49,710,000
SUBTOTAL COSTS	$165,617,000
CONTINGENCY (@ 20%)	$33,123,000
TOTAL CAPITAL COSTS	$198,740,000
PRESENT WORTH COSTS - 1989 (@ 5% for 8 years)	$160,562,000
OPERATION AND MAINTENANCE COSTS (CDFs) (present worth @ 5% for 30 years upon completion)	$862,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000
TOTAL COST - ALTERNATIVE EST-4	$164,800,000

TABLE 7–14
COST ESTIMATE: ALTERNATIVE LHB–4
DREDGE/SOLIDIFY/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	COST
I. DIRECT COST	
A. Dredging	$3,846,000
B. Dewater/Water Treatment	$28,346,000
C. Sediment Treatment	$39,815,000
D. Material Hauling	$2,372,000
E. CDF Construction	$16,034,000
DIRECT COSTS	$90,413,000
II. INDIRECT COST	
A. Health & Safety (@ 5%) Level D Protection [Activities: B,D]	$1,536,000
B. Legal, Administration, Permitting (@ 6%)	$5,425,000
C. Engineering (@ 10%)	$9,041,000
D. Services During Construction (@ 10%)	$9,041,000
E. Turnkey Contractor Fee (@ 15%)	$13,562,000
INDIRECT COSTS	$38,605,000
SUBTOTAL COSTS	$129,018,000
CONTINGENCY (@ 20%)	$25,804,000
TOTAL CAPITAL COSTS	$154,822,000
PRESENT WORTH COSTS – 1989 (@ 5% for 6 years)	$130,971,000
OPERATION AND MAINTENANCE COSTS (CDFs) (@ present worth 5% for 30 years upon completion)	$1,178,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000
TOTAL COST – ALTERNATIVE LHB–4	$135,525,000

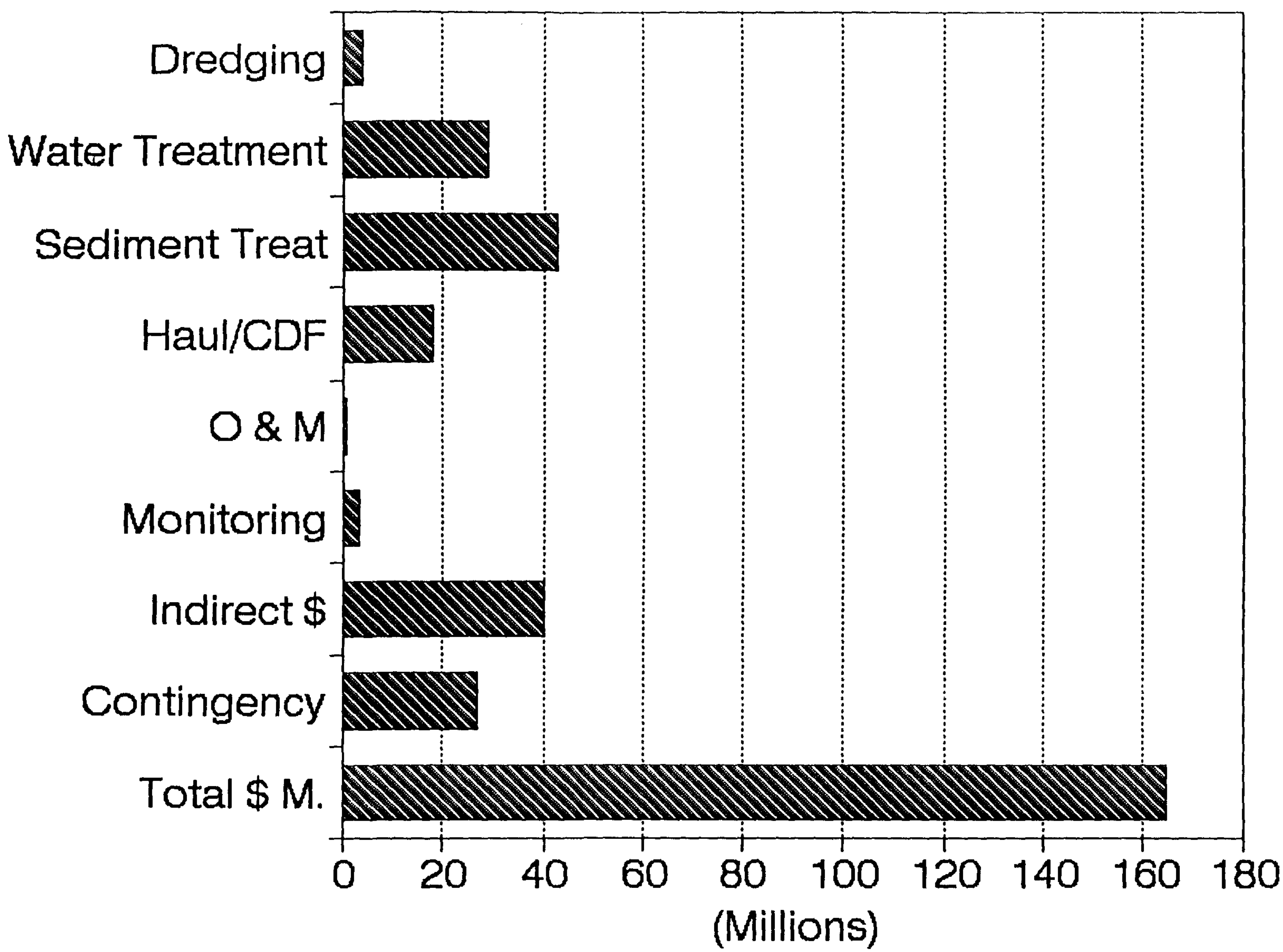

Figure 7-30

Cost Breakdown EST-1

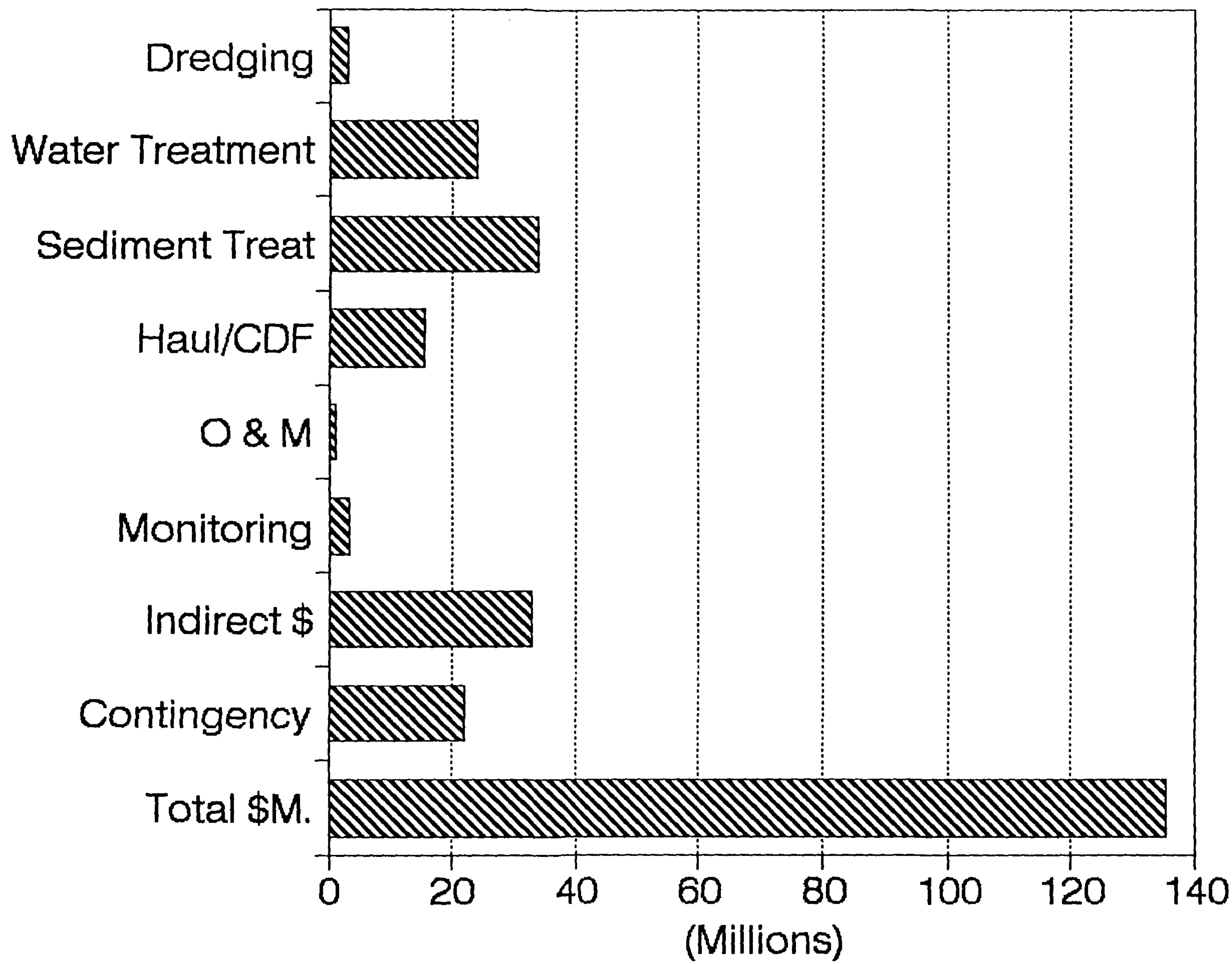

Figure 7-31

Cost Breakdown LUP

created, an additional cost, estimated to be $10 million, wo be incurred. This cost includes dredging 139,000 cy of sedim and planning, construction, and propagation of new wetl habitats along the eastern shoreline of the estuary. The c does not include any additional costs associated with mater handling, CDF construction, dewatering and water treatment, sediment treatment; however, the additional volume of sedim could significantly increase these costs.

A sensitivity analysis of the alternative components w conducted to determine which factors may significantly char the overall costs. For these alternatives, the component th is currently the most costly (solidification) also has a deg of uncertainty in the cost quoted by different vendor Although $100/cy of material was chosen in estimating the co of these alternatives, higher solidification costs may incurred. For this reason, the cost of solidification w increased by 50 percent, producing a 22 percent increase in t cost of Alternative EST-4 from $165 million to $201 millio The cost of Alternatve LHB-4 increases 21 percent from $1 million to $164 million.

Because water treatment costs are also a significant compone of these alternatives, a scenario similar to that analyzed f Alternatives EST-3d and LHB-3d (see Subsection 7.4.6) w performed for Alternatives EST-4 and LHB-4. A 2 percent slur solids concentrations was assumed, which increased the tot cost of Alternative EST-4 by 3 percent to $170 million, and t cost of Alternative LHB-4 to $140 million.

Another analysis, combining the increase in solidification a also the increase in water treatment costs, was performe because the two events could occur simultaneously. The cost Alternative EST-4 increased 25 percent to $206 million, whi Alternative LHB-4 increased to $168 million. Tables 7-15 a 7-16 illustrate how these changes affect the costs of t alternatives.

7.5.7 Compliance with ARARs

The components of Alternatives EST-4 and LHB-4 are the same Alternatives EST-3 and LHB-3, with the addition of solidifyi the dewatered sediments. As discussed in Subsection 7.4. sediments would be excavated to the TCL of 10 ppm PCB Compliance with chemical-specific ARARs through remediation contaminated sediments to 10 ppm is discussed in Subsecti 7.3.7.

National Air Quality Standards (40 CFR 40) and Massachusetts A Pollution and Air Quality regulations (310 CMR 6.00-8.00) wou apply to this alternative. Compliance with air qualit requirements is discussed in Subsection 7.4.7.

TABLE 7-15
SENSITIVITY ANALYSIS: ALTERNATIVE EST-4
DREDGE/SOLIDIFY/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)	COST (2)	COST (3)
DIRECT COSTS				
A. Dredging	$5,098,000	$5,098,000	$5,098,000	$5,098,000
B. Dewater/Water Treatment	$35,973,000	$35,973,000	$39,340,000	$39,340,000
C. Sediment Treatment	$52,778,000	$79,167,000	$52,778,000	$79,167,000
D. Material Hauling	$7,782,000	$7,782,000	$7,782,000	$7,782,000
E. CDF Construction	$14,276,000	$14,276,000	$14,276,000	$14,276,000
TOTAL DIRECT COSTS	$115,907,000	$142,296,000	$119,274,000	$145,663,000
TOTAL INDIRECT COSTS	$49,710,000	$60,530,000	$51,257,000	$62,077,000
CONTINGENCY	$33,123,000	$40,565,000	$34,106,000	$41,548,000
TOTAL CAPITAL COSTS (present worth)	$160,562,000	$196,636,000	$165,327,000	$201,400,000
O&M/MONITORING (present worth)	$4,238,000	$4,238,000	$4,238,000	$4,238,000
TOTAL COST (present worth)	$164,800,000	$200,874,000	$169,565,000	$205,638,000

1. Increase solidification costs by 50%
2. Increase water treatment plant capacity to handle water from 2% solids dredge slurry (item B only)
3. Increase solidification costs by 50% and water treatment plant capacity to handle water from 2% solids dredge slurry

TABLE 7-16
SENSITIVITY ANALYSIS: ALTERNATIVE LHB-4
DREDGE/SOLIDIFY/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)	COST (2)	COST (3)
DIRECT COSTS				
A. Dredging	$3,846,000	$3,846,000	$3,846,000	$3,846,000
B. Dewater/Water Treatment	$28,346,000	$28,346,000	$31,219,000	$31,219,000
C. Sediment Treatment	$39,815,000	$59,722,000	$39,815,000	$59,722,000
D. Material Hauling	$2,372,000	$2,372,000	$2,372,000	$2,372,000
E. CDF Construction	$16,034,000	$16,034,000	$16,034,000	$16,034,000
TOTAL DIRECT COSTS	$90,413,000	$110,320,000	$93,286,000	$113,193,000
TOTAL INDIRECT COSTS	$38,605,000	$46,767,000	$39,928,000	$48,089,000
CONTINGENCY	$25,804,000	$31,417,000	$26,643,000	$32,256,000
TOTAL CAPITAL COSTS (present worth)	$130,971,000	$159,465,000	$135,231,000	$163,723,000
O&M/MONITORING (present worth)	$4,554,000	$4,554,000	$4,554,000	$4,554,000
TOTAL COST (present worth)	$135,525,000	$164,019,000	$139,785,000	$168,277,000

1. Increase solidification costs by 50%
2. Increase water treatment plant capacity to handle water from 2% solids dredge slurry (item B only)
3. Increase solidification costs by 50% and water treatment plant capacity to handle water from 2% solids dredge slurry

Dredging and disposal of sediments would trigger the federal and state location-specific ARARs identified in Subsection 7.4.7. Implementation of this alternative would require compliance with regulations protecting wetlands and floodplains. The procedures and standards required for attainment of these ARARs are discussed in Subsection 7.4.7. If excavation of wetlands is required, this alternative will include the design and construction of new wetlands in the excavated area.

Federal and state action-specific ARARs that would be triggered by this alternative, and actions required for compliance, were identified under Alternatives EST-3 and LHB-3.

As discussed in Subsection 7.4.7, the disposal of dredged sediments contaminated with PCBs is regulated under TSCA. Disposal of the sediments by a method other than incineration or landfilling in a chemical waste requires justification that the alternate method is more practical and protects public health and the environment.

Solidification of contaminated sediments would take place after dewatering and prior to disposal. Following solidification, the waste materials would undergo TCLP analysis. Disposal of material exceeding TCLP maximum concentrations would trigger requirements promulgated under RCRA.

RCRA regulations govern the construction, operation, and closure of CDFs that receive any treatment residuals determined to be hazardous. RCRA General Facility Standards (40 CFR 264.10-264.17) require security measures to control entry at all times, regular inspections to identify problems that could result in release of hazardous waste, and on-the-job training of facility personnel to ensure that activities comply with the goals of RCRA. RCRA standards for surface impoundments include installation of two or more liners and a leachate collection system between liners. Liners must be designed, operated, and constructed to prevent contaminant migration. These requirements also include standards for inspection, monitoring, emergency response, and closure and post-closure care.

Massachusetts Hazardous Waste Regulations would also be appropriate to the design, operation, and closure of CDFs that receive EP Toxicity characteristic wastes. In general, the federal regulations govern remedial activities; however, under CERCLA, more stringent state requirements (e.g., 310 CMR 30.620-Landfills) supersede federal standards.

All site activities, including monitoring, will be carried out pursuant to OSHA standards (29 CFR 1904, 1926) and Massachusetts Right-to-Know regulations (Subsection 4.2.2.3 summarizes these ARARs).

7.5.8 Overall Protection of Public Health and the Environment

Removal, solidification, and on-site disposal of the sediment would permanently reduce the toxicity and mobility of PCBs in the estuarine and marine environment. Public health and environmental risks directly associated with the estuary and the lower harbor/bay would be significantly reduced.

7.6 ALTERNATIVES EST-5 AND LHB-5: REMOVAL, SOLVENT EXTRACTION, AND ON-SITE DISPOSAL

7.6.1 General Description

Alternatives EST-5 and LHB-5 would consist of dredging the estuary and the lower harbor/bay sediment, dewatering the sediment, treating all process wastewater produced during dewatering, and on-site solvent extraction of the dewatered sediment to remove PCBs. The extracted organics would be destroyed by an on-site incinerator. The processed sediment would be subjected to leaching tests to determine whether heavy metals remaining in the extracted sediment exceed maximum allowable leachate concentrations (i.e., TCLP). If it fails the leaching test, the processed sediment would be solidified to immobilize the heavy metals. The processed sediment would then be disposed of in CDF 1 and CDF 3 for the estuary and the lower harbor/bay, respectively. Figure 7-32 is a flow diagram of Alternatives EST-5 and LHB-5. The volume of sediment requiring treatment was estimated to be 528,000 cy for the estuary and 398,000 cy for the lower harbor/bay.

The following paragraphs outline the response actions comprising Alternatives EST-5 and LHB-5. Complete descriptions of the components discussed previously are in the subsections noted.

Dredging. Dredging of estuary and lower harbor/bay sediment and transport to the treatment facility would be conducted as described in Subsection 7.4.1.

Dewatering. Primary and secondary dewatering of the sediment will be conducted as described in Subsection 7.4.1.

Water Treatment. Treatment of CDF effluent and dewatering filtrate will be conducted as described in Subsection 7.4.1.

Solvent Extraction. Solvent extraction is a process in which a soluble substance is leached from a solid matrix with an appropriate solvent. Although PCBs characteristically have relatively low solubilities in water, they are readily soluble in certain organic solvents under appropriate conditions of temperature and/or pressure.
The removal efficiency of solvent extraction depends on the number of extraction steps. The amount of PCBs that can be

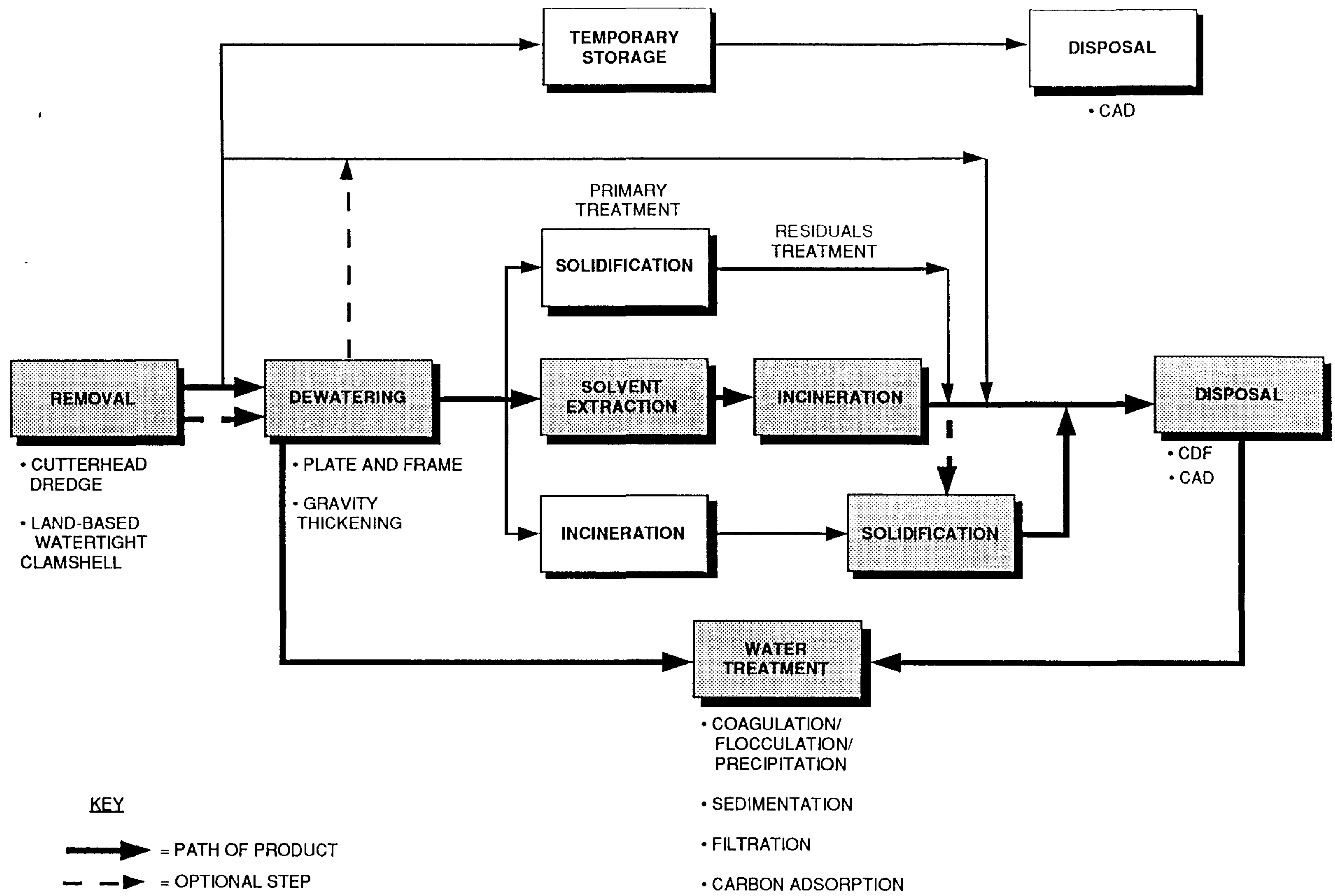

FIGURE 7-32
EST-5 AND LHB-5 DREDGE / SOLVENT EXTRACT / TREAT RESIDUALS / DISPOSE
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

removed from the sediment during any one extraction step is limited by the following (E.C. Jordan Co./Ebasco, 1987c):

- o the contaminant's solubility in the solvent
- o the solvent and sediment mixing efficiency
- o mass transfer coefficients governing the rate at which the contaminant dissolves
- o the time the solvent and sediment are in contact
- o the ability to separate solvent from the sediment
- o the presence of interfering substances in the sediment

Treatment tests were conducted on New Bedford Harbor sediment using two solvent-extraction technologies: the TEA-based BEST process developed by RCC; and the liquified (gas) propane process developed by CF Systems. Treatment tests using the RCC process were conducted on a bench-scale, while the CF Systems process was tested on a pilot-scale as part of the EPA SITE program. Descriptions of these technologies and a brief summary of the test results are in Subsection 5.4.2. Based on treatment test results, only the BEST process was retained as a viable solvent extraction technology. In the following paragraphs, the BEST process has been selected as the example technology for detailed evaluation of sediment treatment using solvent extraction.

Sediment treatment by solvent extraction of PCBs (and the associated oil fraction) from the estuary and lower harbor/bay sediment would begin by batch mixing the dewatered sediment with the appropriate solvent; in this case, TEA. After mixing, the solvent containing PCBs and the sediment containing little or no residual PCBs would be separated by centrifugation and/or gravity settling. The PCB/oil fraction is then separated from the solvent, either by changing the temperature and/or pressure of the solvent which changes the solubility of the PCBs, or by distillation methods. The solvent is subsequently recycled and the PCB/oil fraction destroyed via incineration.

The solvent extraction process shown in Figure 7-33 is a simplified representation of the BEST process. The sediment processing hardware consists of Littleford rotary washer-dryer units. These units are readily available and are used extensively in the chemical-processing industry. Throughput rate for one solvent extraction unit is assumed to be 75 tons (i.e., 61 cy) of dewatered sediment per day. Five units would be necessary to maintain the dredge output rate, and would occupy approximately 2 acres. One large-capacity unit may be constructed to replace the five smaller ones. Figure 7-34 is a

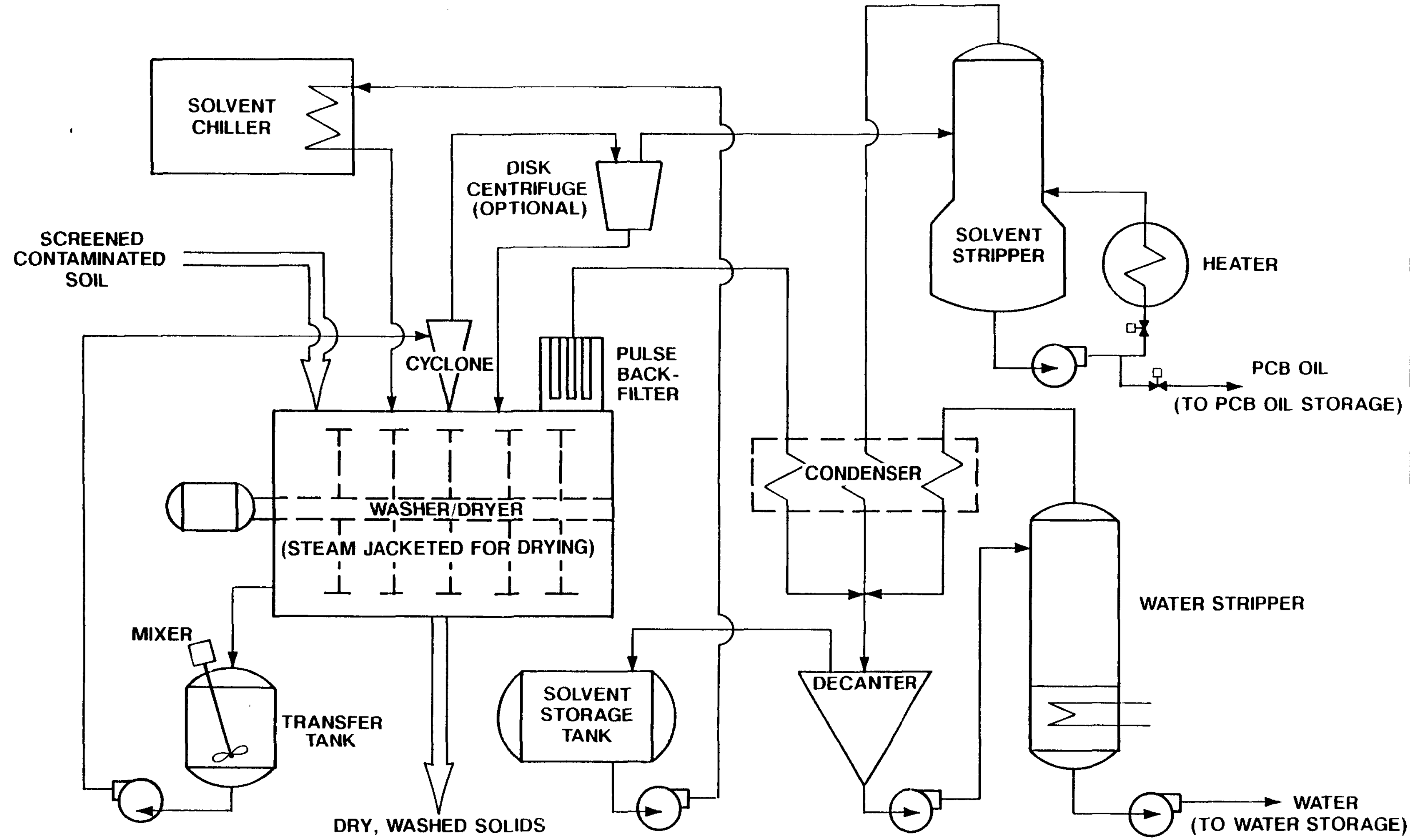

FIGURE 7-33
B.E.S.T.™ SOIL CLEAN-UP UNIT SCHEMATIC
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

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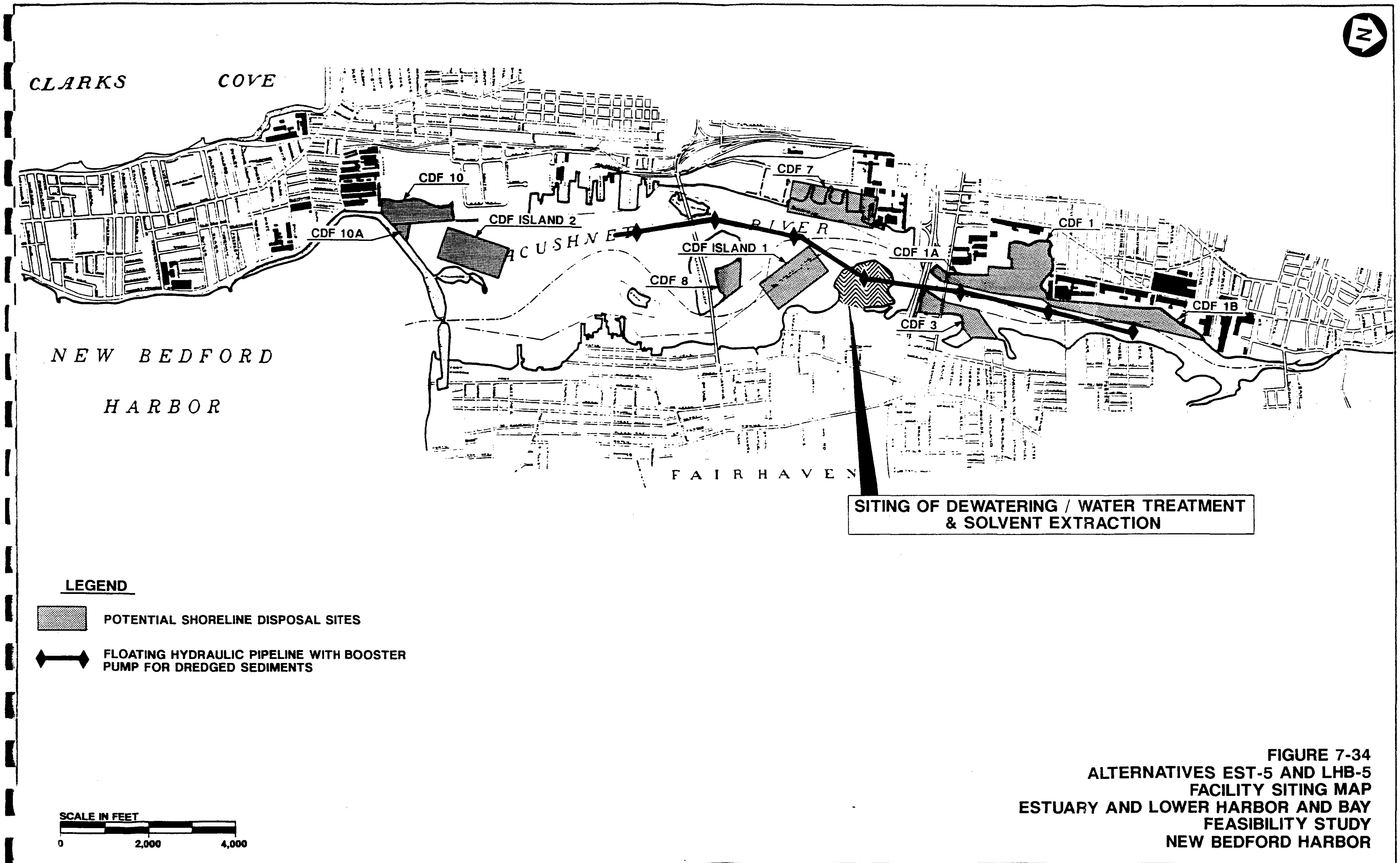


FIGURE 7-34
ALTERNATIVES EST-5 AND LHB-5
FACILITY SITING MAP
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

facility siting map. The dewatered sediment would be separated into three distinct effluent streams: sediment solids, water, and an extract containing PCBs and oil. Approximately 64 cy of dry sediment solids would be generated per day. These solids may contain residual metals. Leaching tests would be used to determine the need for secondary treatment, such as solidification to immobilize the metals, prior to ultimate disposal. The 40,000 gpd of water removed from the sediment would be pumped to the water treatment facility (see Subsection 7.3.1).

Approximately 3,400 gpd of PCB/oil extract would be generated. Because of the duration of this project (i.e., seven years) and the high cost of hauling the oil to a licensed facility, a small mobile incinerator will be sited to treat the PCB/oil extract. Due to the relatively high Btu content and straightforward material handling, the requisite destruction and removal efficiencies (DREs) should be readily achievable. Figure 7-35 depicts the mass balance for this alternative.

Disposal. The treated estuary and harbor/bay sediment would then be hauled by truck and disposed of in CDF 1 and CDF 3, respectively. A cap would be placed over the treated sediment as a final cover. This cap would be graded and seeded to reduce the infiltration of precipitation.

Wetlands Remediation. Removal of wetlands sediment and the establishment of new wetland habitats would be conducted as described in Subsection 7.4.1. Treatment and disposal of the additional 139,000 cy of sediment would be conducted as described herein.

7.6.2 Short-term Effectiveness

Risk to the community (i.e., local residents) is expected to be minimal during implementation of Alternatives EST-5 and LHB-5 for the same reasons discussed for Alternatives EST-3 and LHB-3 (see Subsection 7.4.3).

Workers on-site during remedial activities could be exposed to contaminants by dermal contact and inhalation of airborne particulates or volatilized contaminants. Dermal and inhalation exposure to contaminants could arise as a result of dredging operations (e.g., clearing debris from or unclogging the dredgehead), dewatering the sediment, and solvent extraction operations (e.g., contact with the TEA solvent and PCB/oil fraction). Toxic efforts of TEA and methods to mitigate them are discussed in detail in Subsection 5.3.2.1. To minimize or prevent such exposure, personal protection equipment (i.e., respirators, overalls, and gloves) would be used. In addition, air monitoring would be conducted to ensure worker safety within immediate areas of remedial activity.

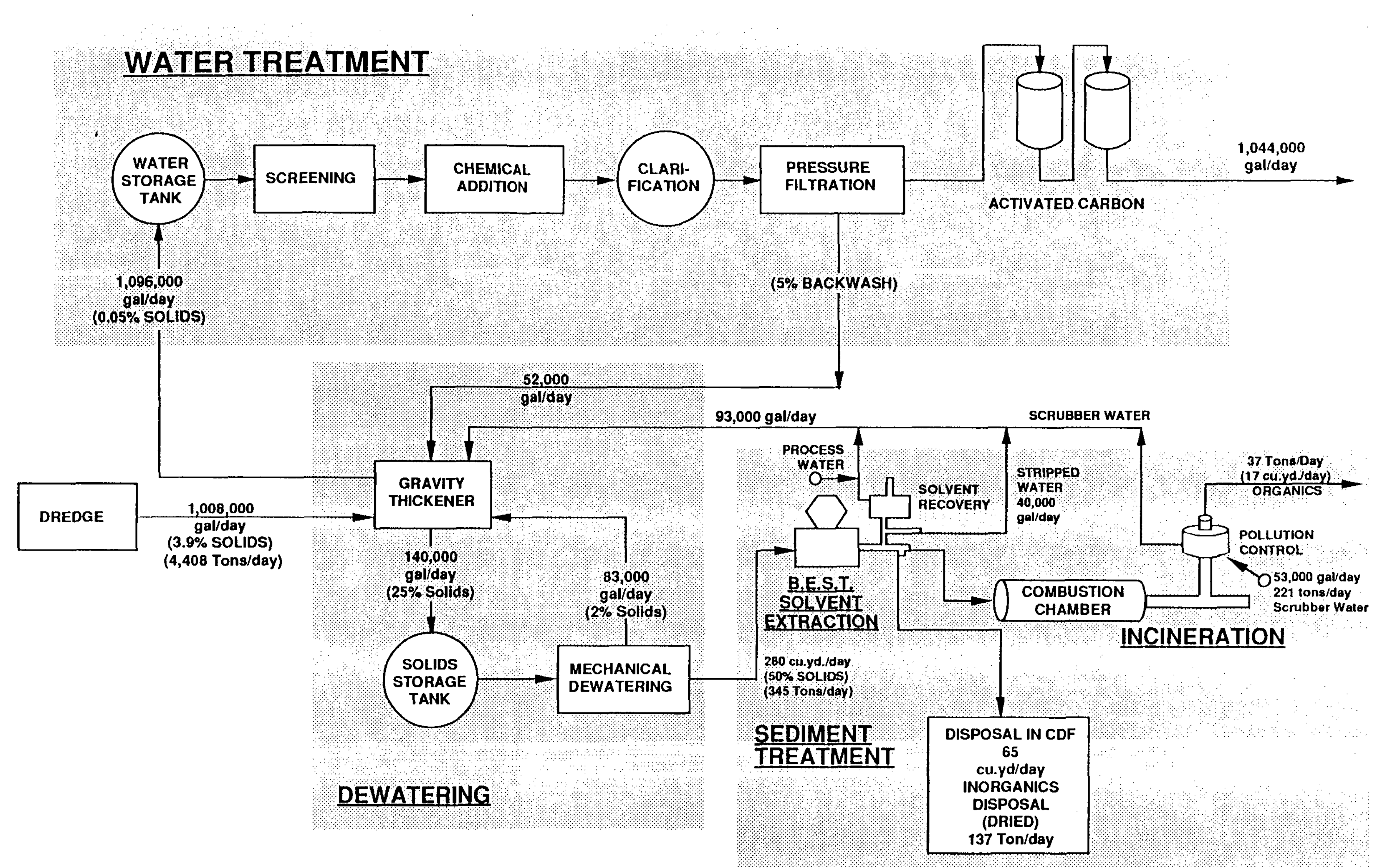


FIGURE 7-35
ALTERNATIVES EST-5 AND LHB-5 SOLVENT EXTRACTION
MASS BALANCE
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

No adverse environmental impacts are expected as a result of dredging of sediment for the same reasons discussed for Alternatives EST-3 and LHB-3 (see Subsection 7.4.3).

7.6.3 Long-term Effectiveness and Permanence

The long-term effectiveness of dredging New Bedford Harbor sediment to remove PCBs is discussed under Alternatives EST-3 and LHB-3 (see Subsection 7.4.3).

Bench-scale tests conducted on New Bedford Harbor sediment indicate that solvent extraction can effectively remove more than 99 percent of the sediment PCBs. However, the processed sediment may require secondary treatment to immobilize metals that would not be extracted. Limited data are available to assess full-scale operation of solvent-extraction technologies.

Disposal of processed sediment in the unlined CDF is not expected to present long-term risks to public health or the environment. Processed sediment containing residual PCBs and metals would constitute the only source of contamination that could potentially be reintroduced into the environment. However, the concentration of PCBs and metals in any leachate generated is expected to be minimal.

Solidification of the processed sediment (as a secondary treatment step to immobilize metals) would further reduce the leaching potential of the PCBs and metals. Placement of a cap on the CDF would reduce the potential for leachate generation due to infiltration of precipitation and surface runoff. Furthermore, attenuation of any residual-contaminated leachate would be expected if leachate generated migrates through the earthen dikes of the CDF. Long-term monitoring and maintenance of the CDF cover and monitoring of the CDF dike would be necessary to assess leachate migration and contaminant concentration.

7.6.4 Reduction in Mobility, Toxicity, and Volume

Solvent extraction of estuary and lower harbor/bay sediment would provide a reduction in both the mobility and volume of PCBs by physically removing them from the sediment. A reduction in PCB toxicity would be achieved by incineration of the PCB/oil extract.

Solidification of processed sediment may be required as a secondary treatment to immobilize residual PCBs and metals. Solidification would achieve a reduction in mobility of the residual PCBs and metals, but would increase the volume of processed residual solids from solvent extraction by approximately 25 percent, depending on the formulation used.

7.6.5 Implementation

7.6.5.1 Technical Feasibility

Constructability. Dredging operations that would occur at the area were proven effective in the USACE dredging pilot study. The dewatering and water treatment technologies are well-developed for the intended application. Prior to final design, bench-scale studies would be required to determine equipment size, chemical dosage, and activated carbon requirements.

Solvent extraction has been demonstrated to be technically feasible for treating New Bedford Harbor sediment. However, limited performance data are available on the ability to scale up solvent extraction to treat 280 cy of sediment daily. Pilot-scale tests of this treatment technology are warranted prior to implementation.

Incineration of the PCB/oil extract is currently the most widely used technology for the destruction of PCB materials. Solidification of the solid process residuals is a common method for reducing the mobility of metals in solid matrices. The process would result in a material that can be easily handled and is stable for disposal.

Reliability. Hydraulic dredging with a cutterhead dredge has been demonstrated to be a reliable technology for use at the New Bedford Harbor site. Downtime during operational periods should be limited to inclement weather or clearing debris from or unclogging the cutterhead (see Subsection 7.4.5.1).

Dewatering and water treatment processes as identified for the alternative have proven very successful in the wastewater and mining industries.

RCC recently completed a pilot-scale demonstration of its new process hardware system at a CERCLA site in Greenville, Ohio. A 10-gallon Littleford unit was used to treat PCB-contaminated soils; the same unit used by Littleford to pilot-test operational and design parameters before full-scale implementation. Results of RCC's tests at the Greenville site indicated that soils contaminated with 150 ppm PCBs were reduced to less than 5 ppm PCBs using the new process system (Weimer, 1989).

Support and Installation. Close coordination with the Harbor Master would be required during dredging activities within the harbor to minimize or avoid impacts on commercial shipping traffic. Tugs, tow vessels, and trucks would be required to move the cutterhead dredge to designated areas. Construction of the hydraulic pipelines would require floating pipes and support crews and vessels.

Ease of Undertaking Additional Remedial Actions. During dredging, potential exists for unacceptable resuspension of the sediment, which could cause the PCBs and metals to migrate in the water column. The use of equipment operating procedures and routine monitoring will help minimize resuspension.

No additional remedial actions are anticipated if the solvent extraction process is successful. However, if solvent extraction does not work on the New Bedford Harbor sediment, mobile incinerators could be brought on-site to treat the dredged material.

Monitoring Considerations. Air and water monitoring during the dredging operation would be conducted as described in Subsection 7.4.5. Appropriate monitoring of dewatering and treatment operations would be necessary to provide protection to workers, the public, and the environment. Periodic sampling of the water discharged from the water treatment facility would be necessary to ensure that system performance standards are met. The three fractions of the solvent extraction process would also be monitored relevant to performance criteria such as TCLP, or residual PCB concentrations.

7.6.5.2 Administrative Feasibility

Coordination among the lead agency (i.e., USACE or EPA), the City of New Bedford, and the Commonwealth of Massachusetts will be important. Coordination would involve active communication, including formal and informal meetings, among these agencies at critical points in the remedial action process. Because no activities would be conducted off-site, permits would not need to be obtained for these alternatives. Although solvent extraction is a relatively new technology, significant opposition from the various agencies is not expected.

7.6.5.3 Availability of Services and Materials

The availability of dredging, dewatering, water treatment, and CDF construction is discussed in Subsection 7.4.5. The new hardware processing system using the Littleford rotary washer-dryer units should be available by early 1990. Because this alternative would require five units (at 100 tons per day output or one large unit), which are not currently available, some delays may be encountered in construction of the equipment before full-scale startup.

7.6.6 Cost

Tables 7-17 and 7-18 present the capital and O&M costs for Alternatives EST-5 and LHB-5. Separate cost components of the alternative include (1) dredging, (2) dewatering and water treatment, (3) solvent extraction of the dewatered sediments,

TABLE 7-17
COST ESTIMATE: ALTERNATIVE EST-5
DREDGE/SOLVENT EXTRACT/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	COST
I. DIRECT COST	
A. Dredging	$5,098,000
B. Dewater/Water Treatment	$35,973,000
C. Sediment Treatment	$143,828,000
D. Material Hauling	$726,000
E. CDF Construction	$2,771,000
DIRECT COSTS	$188,396,000
II. INDIRECT COST	
A. Health & Safety (@ 5%) Level D Protection [Activities: B,D]	$1,835,000
B. Legal, Administration, Permitting (@ 6%)	$11,304,000
C. Engineering (@ 10%)	$18,840,000
D. Services During Construction (@ 10%)	$18,840,000
E. Turnkey Contractor Fee (@ 15%)	$28,259,000
INDIRECT COSTS	$79,078,000
SUBTOTAL COSTS	$267,474,000
CONTINGENCY (@ 20%)	$53,495,000
TOTAL CAPITAL COSTS	$320,969,000
PRESENT WORTH COSTS - 1989 (@ 5% for 8 years)	$259,311,000
OPERATION AND MAINTENANCE COSTS (CDFs) (present worth @ 5% for 30 years upon completion)	$199,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000
TOTAL COST - ALTERNATIVE EST-5	$262,886,000

TABLE 7-18
COST ESTIMATE: ALTERNATIVE LHB-5
DREDGE/SOLVENT EXTRACT/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	COST
I. DIRECT COST	
A. Dredging	$3,846,000
B. Dewater/Water Treatment	$28,346,000
C. Sediment Treatment	$108,698,000
D. Material Hauling	$547,000
E. CDF Construction	$4,833,000
DIRECT COSTS	$146,270,000
II. INDIRECT COST	
A. Health & Safety (@ 5%) Level D Protection [Activities: B,D]	$1,445,000
B. Legal, Administration, Permitting (@ 6%)	$8,776,000
C. Engineering (@ 10%)	$14,627,000
D. Services During Construction (@ 10%)	$14,627,000
E. Turnkey Contractor Fee (@ 15%)	$21,941,000
INDIRECT COSTS	$61,416,000
SUBTOTAL COSTS	$207,686,000
CONTINGENCY (@ 20%)	$41,537,000
TOTAL CAPITAL COSTS	$249,223,000
PRESENT WORTH COSTS - 1989 (@ 5% for 6 years)	$210,830,000
OPERATION AND MAINTENANCE COSTS (CDFs) (@ present worth 5% for 30 years upon completion)	$318,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000
TOTAL COST - ALTERNATIVE LHB-5	$214,524,000

(4) treatment of the extracted PCB oils (the water fraction is sent to the water treatment plant), (5) material transport, and (6) disposal into shoreline CDFs. Each component has been scaled to accommodate the daily dredge output of 280 cy in situ (50 percent solids by weight). The dredging, dewatering/water treatment, and CDF construction are discussed in Subsection 7.4.5.

Figures 7-36 and 7-37 provide a breakdown of the costs of these alternatives. The costs for solvent extraction include equipment and materials necessary to extract the PCBs from the dewatered sediment. The actual costs are based on a bench-scale study conducted by RCC's BEST process using TEA as the solvent to separate the sediment into water, solids, and organics fractions. Using scale-up factors, RCC determined five 100-ton-per-day units would be required to maintain the dredge output rate. Mobilization/demobilization costs are considered in the process costs, as well as incineration of the spent carbon and treatment of the water at the water treatment plant.

Health and safety costs, where not included as part of a line item within a given component, have been added as other direct costs. For this alternative, Level D health and safety factors were added to the water treatment and material transport components at 5 percent of the overall cost of that item.

Other costs have also been added to the total cost of implementing this alternative. Legal, administrative, and permitting costs are anticipated to add an additional 6 percent of the total capital and O&M costs. Engineering and services during remediation are anticipated to cost an additional 10 percent each. Turnkey contractor fees are anticipated to cost 15 percent. Finally, a 20 percent contingency was added to the subtotal of these items to derive the final cost per alternative. The indirect costs and contingency are based on standard engineering practices using undeveloped design conditions.

If it is determined that the PCB-contaminated sediment in the wetlands will need to be removed and new wetland habitats created, an additional cost, estimated to be $10 million, would be incurred. This cost includes dredging 139,000 cy of sediment and planning, construction, and propagation of new wetland habitats along the eastern shoreline of the estuary. The cost does not include any additional costs associated with material handling, CDF construction, dewatering and water treatment, or sediment treatment; however, the additional volume of sediment could significantly increase these costs.

A sensitivity analysis for the alternative components was conducted to determine which factors may significantly change the overall costs. For these alternatives, the component that

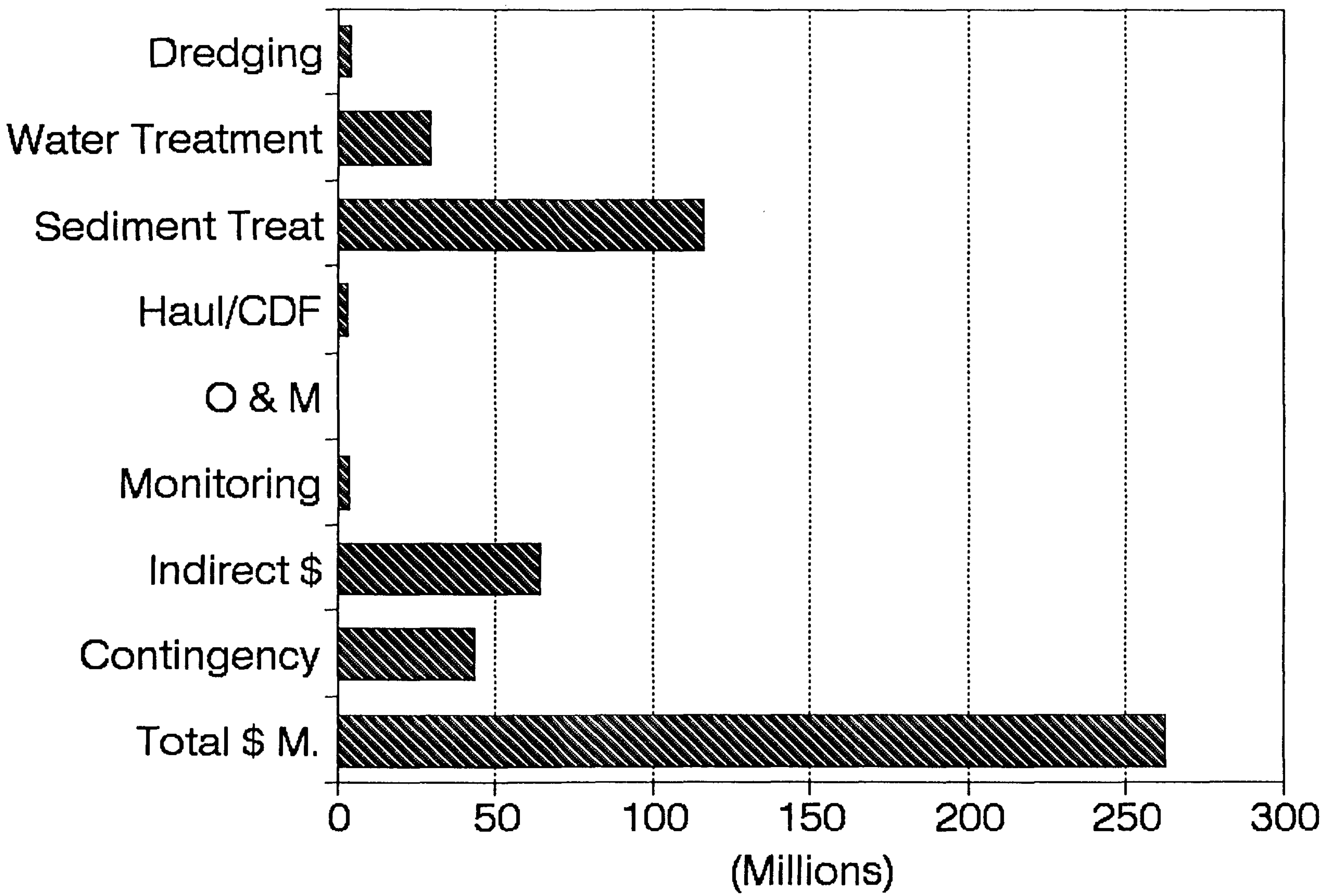


Figure 7-36

Cost Estimate EST-5
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

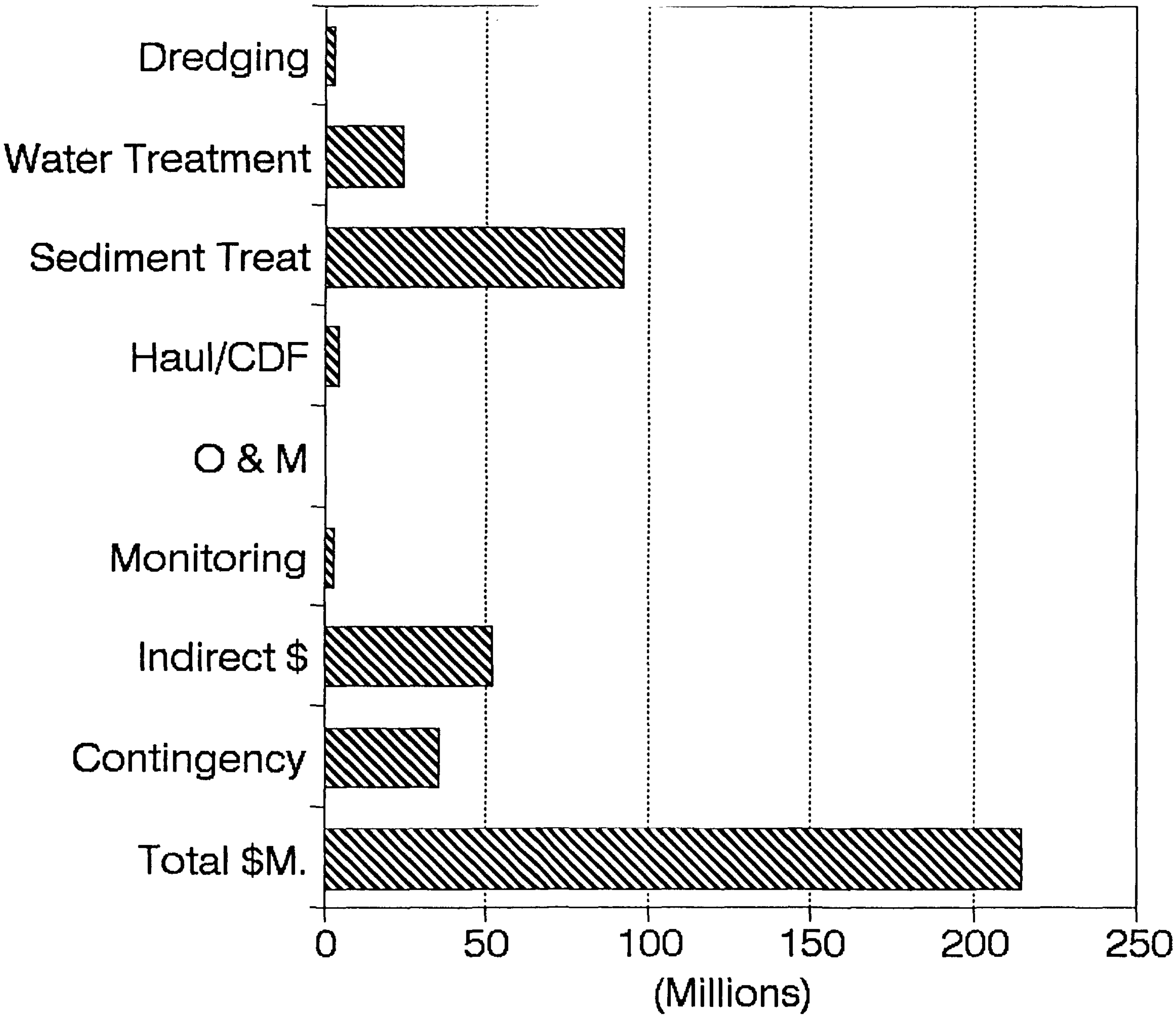


Figure 7-37

Cost Breakdown LHB-5
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

is currently the most expensive also has a degree of uncertainty regarding scale-up to the full-scale operation because RCC's BEST process is a relatively new and innovative technology. For the original cost estimate, a cost of $200/cy was quoted to perform the extraction at full-scale, as a typical value. For the sensitivity analysis, a unit cost 10 percent greater was used, because $220/cy was quoted as an upper limit for the BEST process for volumes greater than 20,000 cy. A 5 percent increase in total cost reflects this 10 percent increase in sediment treatment cost, from $263 million to $277 million for Alternative EST-5, and from $215 million to $226 million for Alternative LHB-5.

Another factor within the sediment treatment component that is subject to change is the cost of incinerating the PCB/oil residue. The cost estimate was based on $0.33/lb; however, quotes have been received as high as $0.77/lb. This higher value was used in this analysis, yielding an 18 percent increase in the total cost of Alternative EST-5 (to $309 million), and a 17 percent increase in the total cost of Alternative LHB-5 (to $251 million). Tables 7-19 and 7-20 illustrate the effects of these changes.

In the event that the extracted PCBs are to be incinerated off-site, an additional $10 million would be incurred (i.e., an additional 29 percent for incineration). This would amount to an overall increase in cost of approximately 6 percent. This variation on incineration also means that in excess of 1,800 trips of approximately 1,000 miles would be incurred to haul the extract.

7.6.7 Compliance with ARARs

Chemical-specific ARARs applicable to this alternative for the surface water and biota of the estuary and the lower harbor/bay were identified and discussed for compliance in Subsection 7.4.7. As discussed in Subsection 7.4.7, federal and state air pollution control and air quality regulations require application of Best Available Control Technology (BACT) for any emissions from the solvent-extraction unit to minimize impacts to existing air quality.

Location-specific ARARs that will be triggered by dredging and construction of the CDFs include federal and state wetlands and floodplains protection regulations. Location-specific ARARs are discussed in Subsection 7.4.7. If excavation of wetlands is required, this alternative will include the design and construction of new wetlands in the excavated areas.

This alternative is similar to Alternatives EST-5 and LHB-5, in that contaminated sediments will be treated after dewatering and before disposal. TSCA regulations governing disposal of

TABLE 7-19
SENSITIVITY ANALYSIS: ALTERNATIVE EST-5
DREDGE/SOLVENT EXTRACT/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)	COST (2)
DIRECT COSTS			
A. Dredging	$5,098,000	$5,098,000	$5,098,000
B. Dewater/Water Treatment	$35,973,000	$35,973,000	$35,973,000
C. Sediment Treatment	$143,828,000	$154,383,000	$177,616,000
D. Material Hauling	$726,000	$726,000	$726,000
E. CDF Construction	$2,771,000	$2,771,000	$2,771,000
TOTAL DIRECT COSTS	$188,396,000	$198,951,000	$222,184,000
TOTAL INDIRECT COSTS	$79,078,000	$83,405,000	$92,930,000
CONTINGENCY	$53,495,000	$56,471,000	$63,023,000
TOTAL CAPITAL COSTS (present worth)	$259,311,000	$273,739,000	$305,497,000
O&M/MONITORING (present worth)	$3,575,000	$3,575,000	$3,575,000
TOTAL COST (present worth)	$262,886,000	$277,314,000	$309,072,000

1. Increase solvent extraction costs by 10%
2. Increase PCB incineration cost to $0.77/lb (from $0.33/lb)

TABLE 7-20
SENSITIVITY ANALYSIS: ALTERNATIVE LHB-5
DREDGE/SOLVENT EXTRACT/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)	COST (2)
DIRECT COSTS			
A. Dredging	$3,846,000	$3,846,000	$3,846,000
B. Dewater/Water Treatment	$28,346,000	$28,346,000	$28,346,000
C. Sediment Treatment	$108,698,000	$116,661,000	$134,188,000
D. Material Hauling	$547,000	$547,000	$547,000
E. CDF Construction	$4,833,000	$4,833,000	$4,833,000
TOTAL DIRECT COSTS	$146,270,000	$154,233,000	$171,760,000
TOTAL INDIRECT COSTS	$61,416,000	$64,680,000	$71,867,000
CONTINGENCY	$41,537,000	$43,783,000	$48,725,000
TOTAL CAPITAL COSTS (present worth)	$210,830,000	$222,227,000	$247,315,000
O&M/MONITORING (present worth)	$3,694,000	$3,694,000	$3,694,000
TOTAL COST (present worth)	$214,524,000	$225,921,000	$251,009,000

1. Increase solvent extraction costs by 10%
2. Increase PCB incineration cost to $0.77/lb (from $0.33/lb)

dredged, PCB-contaminated material are presented in Subsection 7.4.7. Under current TSCA regulations, solvent extraction would be considered an alternative treatment technology and would need to achieve a level of performance equivalent to incineration (40 CFR 761.70) before disposal. However, EPA is currently considering a 2-ppm PCB residual level for alternate treatment technologies.

The extraction residuals containing the PCBs would be incinerated. This part of the process would be subject to TSCA operating and performance standards for incinerators.

Process liquids generated during the solvent extraction process would be subject to the CWA and Massachusetts Surface Water Quality Standards, and would require treatment prior to discharge.

Treated sediments would undergo TCLP analysis. Materials exceeding the maximum concentrations would be subject to RCRA disposal requirements and Massachusetts Hazardous Waste Regulations. The ARARs appropriate to disposal of potentially hazardous treatment residuals are discussed in Subsection 7.5.7.

All site activities, including monitoring, will be carried out pursuant to OSHA standards (29 CFR 1904 and 1926) and Massachusetts Right-to-Know regulations (Subsection 4.2.2.3 summarizes these ARARs).

7.6.8 Overall Protection of Public Health and the Environment

Removal, solvent extraction, and on-site disposal of the sediment would permanently reduce the toxicity and mobility of PCBs in the estuarine and marine environment. Public health and environmental risks directly associated with the estuary and the lower harbor/bay would be significantly reduced.

7.7 ALTERNATIVES EST-6 AND LHB-6: REMOVAL, INCINERATION, AND ON-SITE DISPOSAL

7.7.1 General Description

Alternatives EST-6 and LHB-6 would consist of dredging the estuary and the lower harbor/bay sediment, dewatering the sediment and treatment of all process wastewaters produced during dewatering, and on-site incineration of the dewatered sediment to destroy the PCBs. The incinerated residue would be subjected to leaching tests (e.g., EP Toxicity or TCLP) to determine whether heavy metals in the ash exceed maximum allowable concentrations in any leachate generated. If it fails the leaching test, the ash would be solidified to immobilize the heavy metals. The incinerated residue would be disposed of in

CDF 1 and in CDFs 4 and 8 for the estuary and the harbor/bay, respectively. Figure 7-38 is a process flow diagram of Alternatives EST-6 and LHB-6.

The volume of sediment requiring treatment was estimated to be 528,000 cy for the estuary and 398,000 cy for the lower harbor/bay.

The following paragraphs outline the response actions comprising Alternatives EST-6 and LHB-6. Complete descriptions of the components discussed previously are in the subsections noted.

Dredging. Dredging of the sediment and transport to the treatment facility would be conducted as described in Subsection 7.4.1.

Dewatering. Primary and secondary dewatering of the sediment would be conducted as described in Subsection 7.4.1.

Water Treatment. Treatment of CDF effluent and dewatering filtrate would be conducted as described in Subsection 7.4.1.

Incineration. Dewatered sediment would be incinerated to destroy PCBs. Three incinerator technologies are applicable for the destruction of PCBs in sediment: rotary kiln, infrared, and fluidized bed. A description and detailed evaluation of each technology were reported by Jordan/Ebasco (E.C. Jordan Co./Ebasco, 1987c). All three incinerators have the same operational characteristics and are capable of achieving 99.9999 percent destruction of contaminants, as required by federal standards. The primary difference between these technologies is the material handling mechanism in the incineration chamber. The ultimate selection of an incinerator will depend largely on equipment availability.

Five skid or trailer-mounted 75-ton-per-day incinerator units or one large fixed unit would be used. Approximately seven years would be required to incinerate the sediment from the estuary. Sediment entering the incinerator would be 50 percent solids by weight. An auxiliary fuel (e.g., fuel oil or natural gas) would be added to the sediment feed to facilitate combustion.

Incineration of PCB-contaminated sediment would probably be conducted in two stages. In the first stage, sediment would be fed into a primary combustion chamber. The temperature in this chamber is maintained at 1,600 to 1,800 degrees Fahrenheit. Solids residence times vary from 15 to 45 minutes. In the second stage, combustion gases generated in the primary chamber flow to a secondary chamber where the gases are heated to 2,400 degrees Fahrenheit for more than 2 seconds. The gases then flow into the air-pollution control system. When conducted under proper operating conditions, incineration of PCBs (and the

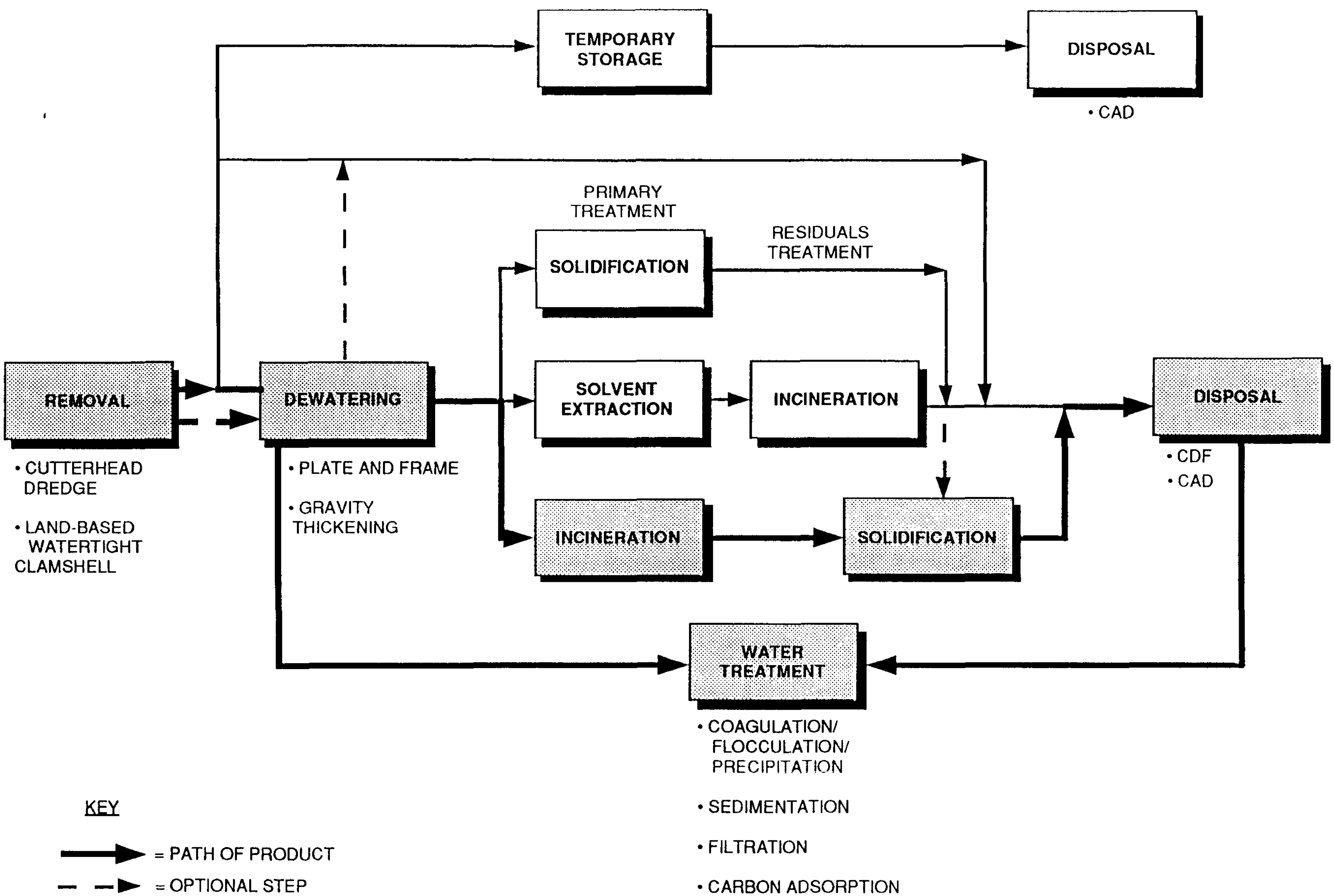


FIGURE 7-38
EST-6 AND LHB-6 DREDGE / INCINERATE / TREAT RESIDUALS / DISPOSE
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

auxiliary fuel) is completed without the formation of potentially hazardous by-products of combustion.

Air-pollution control equipment is required for all three incinerator systems to meet air emissions standards for hydrogen chloride and particulates. Both the infrared and rotary kiln systems generally use a combination of a packed tower to control hydrogen chloride and a wet venturi scrubber, baghouse, or electrostatic precipitator to control particulates. The fluidized bed process can control hydrogen chloride by introducing a caustic in the reactor bed. Therefore, only a baghouse or electrostatic precipitator is necessary to control particulates. After treatment for hydrogen chloride and particulates, the combustion gases are released to the air through a stack.

The air pollution control system for all three incinerators produces a low-volume wastewater stream containing sodium or calcium chloride and suspended solids. This stream would be pumped to the water treatment facility for treatment before discharge.

Solidification. Incineration of the PCB-contaminated sediment would produce a large volume of residual ash, which would contain metals at concentrations near those observed in the untreated sediment. These metals may become oxidized as a result of incineration, thereby allowing them to become more mobile. TCLP analysis would be conducted on the ash to determine whether metals leaching from the ash would exceed the maximum allowable leachate concentrations, thereby constituting a hazardous waste. If the ash fails the leaching test, solidification would be necessary as a secondary treatment step to immobilize the metals.

Solidification would be used as a secondary treatment to physically and chemically stabilize the metals by binding them in a solid matrix. This treatment is a common technology for stabilizing metals. Although the USACE S/S studies demonstrated that some metals were mobilized during the treatment, the primary purpose of the study was to solidify the organics, principally PCBs. It is anticipated that among the numerous commercial processes available, a formulation of solidifying agents is available to immobilize all heavy metals. Additional bench-scale tests to determine the correct formulation would be required before final design.

Solidification of the incinerator ash would be accomplished using conventional cement-mixing equipment. Based on a 50 percent solids feed containing 6 percent combustible organics in the feed, 64 cy of residual ash would be generated for every 280 cy of sediment incinerated (80 tons). Adding a half ton of solidifying agent to every ton of incinerator ash would produce approximately 120 tons per day of solidified ash. This is equivalent to approximately 80 cy of residual material, with an assumed density of 1.25 tons per cy (Church, 1981). Figure 7-39 is a siting map for the incineration and solidification facilities, and Figure 7-40 depicts the mass balance for this alternative.

Disposal. The solidified ash would be hauled by truck to CDF 1 and CDFs 4 and 8 for the estuary and the lower harbor/bay, respectively. A cap would be placed over the solidified ash as a final cover. This cap would be graded and seeded to reduce the infiltration of precipitation. If, however, the solidified ash is a RCRA waste, then it will be disposed of in accordance with RCRA/TSCA regulations.

Wetlands Remediation. Removal of wetlands sediment and the establishment of new wetland habitats would be conducted as described in Subsection 7.4.1. Treatment and disposal of the additional 139,000 cy of sediment would be conducted as described herein.

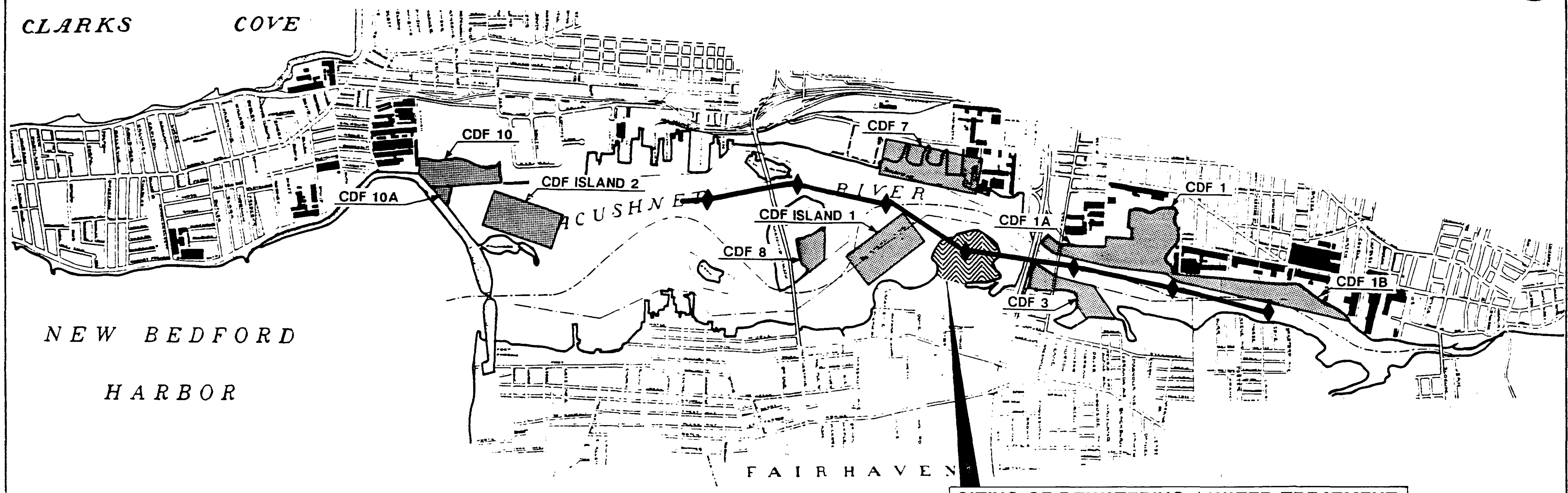
7.7.2 Short-term Effectiveness

Risk to the community is expected to be minimal during implementation of Alternatives EST-6 and LHB-6 for the same reasons discussed for Alternatives EST-3 and LHB-3 (see Subsection 7.4.3).

To minimize or prevent worker exposure during on-site remedial activities, personal protection equipment (i.e., respirators, overalls, and gloves) would be used. These precautions would limit exposure to contaminants by dermal contact and the inhalation of airborne particulates or volatilized contaminants. Dermal and inhalation exposure to contaminants could arise as a result of dredging operations (e.g., clearing of debris from or unclogging the dredgehead), dewatering the sediment, and material handling during incineration of sediment. In addition, ambient air monitoring and monitoring of incinerator stack gases and fugitive emissions would be conducted to ensure worker safety within immediate areas of remedial activity.

No adverse environmental impacts are expected as a result of sediment dredging for the reasons discussed in Alternatives EST-3 and LHB-3 (see Subsection 7.4.3).

Based on an incinerator throughput rate of 75 tons per day, approximately eight years would be required to complete the remedial activities for the estuary and six years for the harbor/bay, as described in Alternatives EST-6 and LHB-6.



LEGEND

POTENTIAL SHORELINE DISPOSAL SITES

FLOATING HYDRAULIC PIPELINE WITH BOOSTER PUMP FOR DREDGED SEDIMENTS

SCALE IN FEET
0 2,000 4,000

FIGURE 7-39
ALTERNATIVES EST-6 AND LHB-6
INCINERATION
FACILITY SITING MAP
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

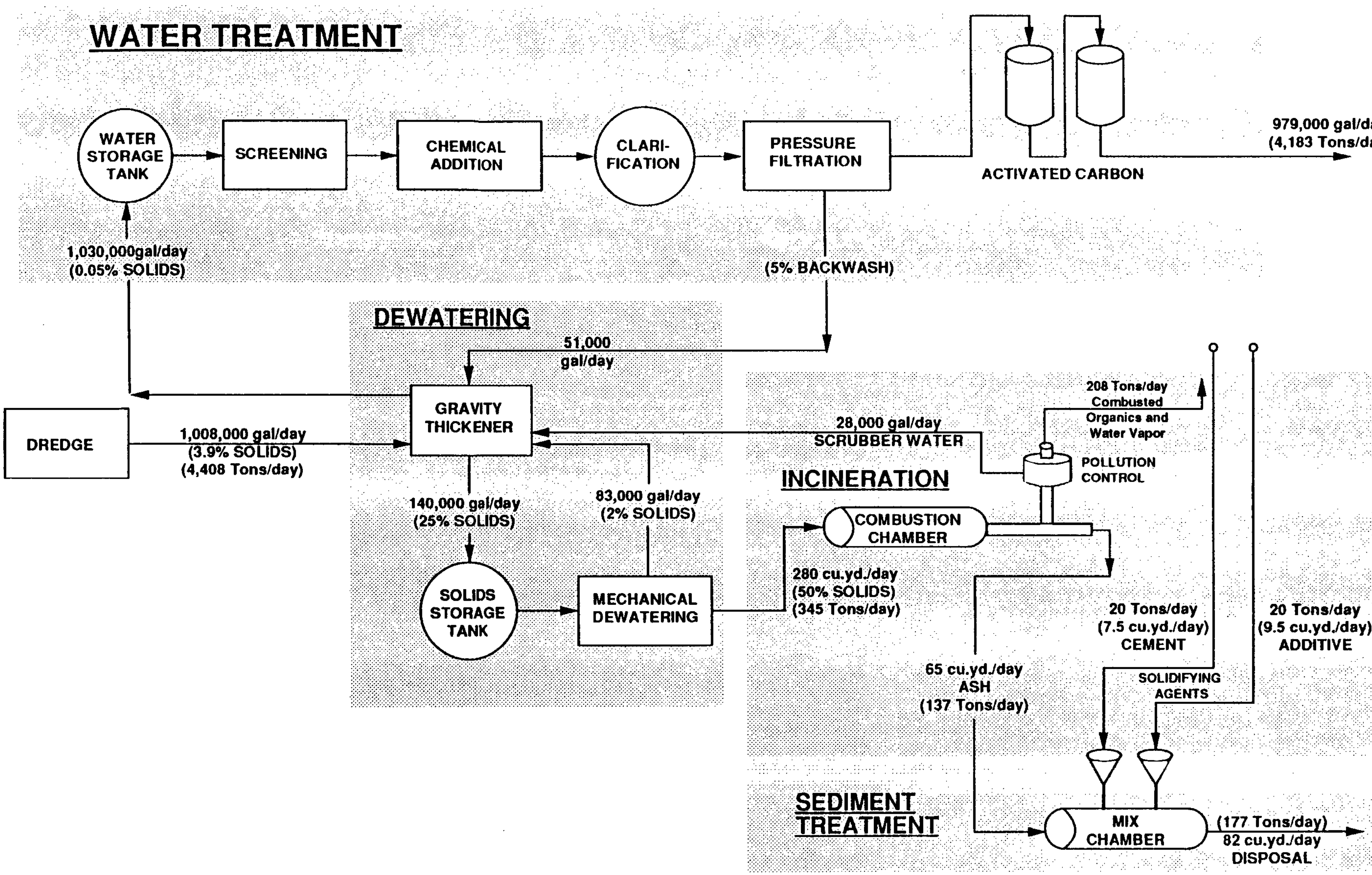


FIGURE 7-40
ALTERNATIVES EST-6 AND LHB-6
MASS BALANCE
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

7.7.3 Long-term Effectiveness and Permanence

The long-term effectiveness of dredging New Bedford Harbor sediment to remove PCBs is discussed under Alternatives EST-3 and LHB-3 (see Subsection 7.4.4).

Incineration is a thoroughly proven technology for the destruction of organics, and is therefore expected to provide a complete and permanent remedy for treating PCB-contaminated sediment. Solidification as a secondary treatment for the incinerator ash is expected to provide an effective means of immobilizing metals if the ash fails the leaching test. However, the long-term permanence of solidification is uncertain because few long-term performance data exist to address this issue.

Disposal of processed sediment in the unlined CDF is not expected to present long-term risks to public health or the environment. Leaching of metals in the disposed sediment would constitute a possible source of contamination that may be reintroduced into the environment. The concentration of metals in the leachate is expected to be minimal. Solidification of the incinerator ash would further reduce the leaching potential of residual metals if leaching tests indicated that metals would be of concern. Placement of a cap on the CDF would also reduce the potential for leachate generation due to infiltration of precipitation and surface runoff. Furthermore, attenuation of leachate metals concentrations is expected as the leachate migrates through the earthen dikes of the CDF. Long-term monitoring and maintenance of the CDF cover and monitoring of the CDF dike would be necessary to assess leachate migration and contaminant concentration.

7.7.4 Reduction in Mobility, Toxicity, and Volume

Incineration of contaminated sediment would permanently destroy PCBs, thereby reducing both toxicity and mobility. Incineration would also reduce the final volume of sediment by destroying the organics and vaporizing the water retained in the filter cake (after dewatering). However, incineration could result in an increase in the mobility of metals, which become oxidized during this treatment process. Secondary treatment of the incinerator ash (e.g., solidification) may be required to reduce the mobility of metals.

7.7.5 Implementation

7.7.5.1 Technical Feasibility

Constructability. USACE demonstrated the effectiveness of the dredging operations that would occur in its dredging pilot study. The dewatering and water treatment technologies are well-developed for the intended application. Prior to final design, bench-scale studies would be required to determine equipment size, chemical dosage, and activated carbon requirements.

Incineration is technically feasible and has been proven for destruction of organic compounds, including PCBs in soil, over a range of contaminant levels similar to those in New Bedford Harbor. The sediment is not expected to have significant energy content; therefore, auxiliary fuels would be required to achieve the necessary temperatures.

The solidification process that may need to be used to stabilize the incinerator ash is a common process for treatment of metals in solid matrices. The USACE bench-scale tests of untreated sediment from the Acushnet River Estuary indicate that solidification is an effective method for immobilizing PCBs and some heavy metals. However, because the emphasis of the USACE study was to immobilize the PCBs, and the organic constituents would no longer be present in the ash, additional bench-scale tests are needed to determine which formulations of proprietary or conventional cement mixtures would most effectively immobilize the metals of concern within the incinerator ash.

Reliability. Hydraulic dredging with a cutterhead dredge has been demonstrated to be a reliable technology for use at the New Bedford Harbor site. Downtime during operational periods should be limited to inclement weather or to downtime due to clearing debris from or unclogging the cutterhead or pipeline.

Incineration systems are highly reliable due to the sophistication of the technology employed and the degree of monitoring and control practiced. A DRE of 99.9999 percent for various organic compounds and PCBs has been demonstrated. A trial burn would need to be completed before implementation to optimize operating parameters. Typical downtime estimates for incinerators are 20 to 30 percent for a system operating 24 hours per day, seven days per week; this is required for systems maintenance and inspections.

The solidification bench-scale studies were conducted on untreated Hot Spot Area and composited sediment. Before final design, bench-scale studies would need to be performed on ash resulting from the incineration of sediment during test burns. These studies will be used to evaluate optimum ash/admixture proportions. The resulting solidified ash would be disposed of in a CDF.

Support and Installation. Extensive coordination with the Harbor Master would be required during dredging activities to minimize or avoid impacts on commercial shipping traffic. Tugs, tow vessels, and trucks would be required to move the cutterhead dredge to designated areas. Construction of the hydraulic pipelines would require floating pipes and support crews and vessels. Site preparation and land acquisition would be required for the installation of the incineration plants, dewatering/water treatment facilities, and solidification plants.

The incineration process requires a pretreatment step to dewater sediments and post-treatment for the ash, scrubber water, and gaseous effluents. These treatment steps would be necessary to comply with ARARs and other institutional constraints.

Before passing sediments through the incinerator, dewatering is necessary to remove as much water from the sediments as possible. Heat required to evaporate the water in the combustion chamber represents a large fraction of the total heat necessary to incinerate the sediments. Reducing the amount of water in the slurry will have two benefits: first, the fuel saved by not evaporating the water represents a direct savings in operating cost; and second, the time required to process the sediments is reduced, resulting in higher throughputs and less total operating time. For the purpose of this evaluation, a dewatering step involving mechanical dewatering is assumed and the process is evaluated under water-feed conditions of 50 percent solids and 50 percent water by weight.

<u>Additional Remedial Action</u>. No remedial actions are anticipated following incineration of the sediment because the organics would be destroyed. The heavy metals in the residual ash are expected to be immobilized by solidification following treatment operations, if necessary.

<u>Monitoring Considerations</u>. Air and water monitoring during the dredging, dewatering, and water treatment operations would be conducted as described in Subsection 7.4.5.

Incineration systems require sophisticated monitoring instrumentation to control the combustion process and monitor stack emissions. Monitoring instruments provide data on the following parameters:

- fuel feed rates and pressures
- waste feed rates
- primary and secondary combustion chamber temperatures
- operating conditions of air-pollution control equipment
- flue gas concentrations of oxygen, carbon monoxide, carbon dioxide, total hydrocarbons, hydrogen chloride, and total particulates

- combustion air flow rates

These data are used to optimize the efficiency of combustion, and should provide adequate information to assess system performance.

7.7.5.2 Administrative Feasibility

Coordination among the lead agency (i.e., USACE or EPA), the City of New Bedford, and the Commonwealth of Massachusetts will be important. Coordination would involve active communication, including formal and informal meetings, among these agencies at critical points in the remedial action process. Because all activities would be conducted on-site, no permits are needed for this alternative. Opposition from the various agencies is not anticipated; however, the New Bedford Harbor Community Work Group has raised some concerns regarding incineration.

7.7.5.3 Availability of Services and Materials

The availability of services and materials for dredging, dewatering, water treatment, and CDF construction is discussed in Subsection 7.4.5. Mobile incineration units capable of treating 75 tons of sediment per day are currently available. Approximately five infrared incinerators, five rotary kilns, and two fluidized bed units will be available in 1990. Any of these units could be mobilized on-site within a two-month period.

7.7.6 Cost

Tables 7-21 and 7-22 present the capital and O&M costs estimated for Alternatives EST-6 and LHB-6. Separate cost components of this alternative include dredging, dewatering and water treatment, incineration of the dewatered sediments, residual solids transport, and disposal into shoreline CDFs. Each component has been scaled to accommodate the daily dredge output of 280 cy in situ (50 percent solids by weight). The dredging, dewatering/water treatment, and CDF construction are discussed in Subsection 7.4.5.

Figures 7-41 and 7-42 itemize costs for these alternatives. The costs for incineration include equipment and materials necessary to burn the PCBs contained in the dewatered sediment. The actual costs are based on vendor information and cost bids for similar clean-up work. Costs are given per ton treated and reflect estimates from nine separate sources. The actual costs vary depending on the amount of material that will require treatment. The costs include capital and O&M costs, mobilization/demobilization costs, contingencies, and profit. Included in the cost of sediment treatment is solidifying the residual ash to immobilize the metals present.

TABLE 7–21
COST ESTIMATE: ALTERNATIVE EST–6
DREDGE/INCINERATE/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	COST
I. DIRECT COST	
A. Dredging	$5,098,000
B. Dewater/Water Treatment	$35,973,000
C. Sediment Treatment	$191,583,000
D. Material Hauling	$726,000
E. CDF Construction	$2,771,000
DIRECT COSTS	$236,151,000
II. INDIRECT COST	
A. Health & Safety (@ 5%) Level D Protection [Activities: B,D]	$1,835,000
B. Legal, Administration, Permitting (@ 6%)	$14,169,000
C. Engineering (@ 10%)	$23,615,000
D. Services During Construction (@ 10%)	$23,615,000
E. Turnkey Contractor Fee (@ 15%)	$35,423,000
INDIRECT COSTS	$98,657,000
SUBTOTAL COSTS	$334,808,000
CONTINGENCY (@ 20%)	$66,962,000
TOTAL CAPITAL COSTS	$401,770,000
PRESENT WORTH COSTS – 1989 (@ 5% for 8 years)	$324,591,000
OPERATION AND MAINTENANCE COSTS (CDFs) (present worth @ 5% for 30 years upon completion)	$199,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000
TOTAL COST – ALTERNATIVE EST–6	$328,166,000

TABLE 7-22
COST ESTIMATE: ALTERNATIVE LHB-6
DREDGE/INCINERATE/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	COST
I. DIRECT COST	
A. Dredging	$3,846,000
B. Dewater/Water Treatment	$28,346,000
C. Sediment Treatment	$144,528,000
D. Material Hauling	$547,000
E. CDF Construction	$4,833,000
DIRECT COSTS	$182,100,000
II. INDIRECT COST	
A. Health & Safety (@ 5%) Level D Protection [Activities: B,D]	$1,445,000
B. Legal, Administration, Permitting (@ 6%)	$10,926,000
C. Engineering (@ 10%)	$18,210,000
D. Services During Construction (@ 10%)	$18,210,000
E. Turnkey Contractor Fee (@ 15%)	$27,315,000
INDIRECT COSTS	$76,106,000
SUBTOTAL COSTS	$258,206,000
CONTINGENCY (@ 20%)	$51,641,000
TOTAL CAPITAL COSTS	$309,847,000
PRESENT WORTH COSTS – 1989 (@ 5% for 6 years)	$262,115,000
OPERATION AND MAINTENANCE COSTS (CDFs) (present worth @ 5% for 30 years upon completion)	$318,000
MONITORING PROGRAM (present worth @ 5% for 30 years)	$3,376,000
TOTAL COST – ALTERNATIVE LHB-6	$265,809,000

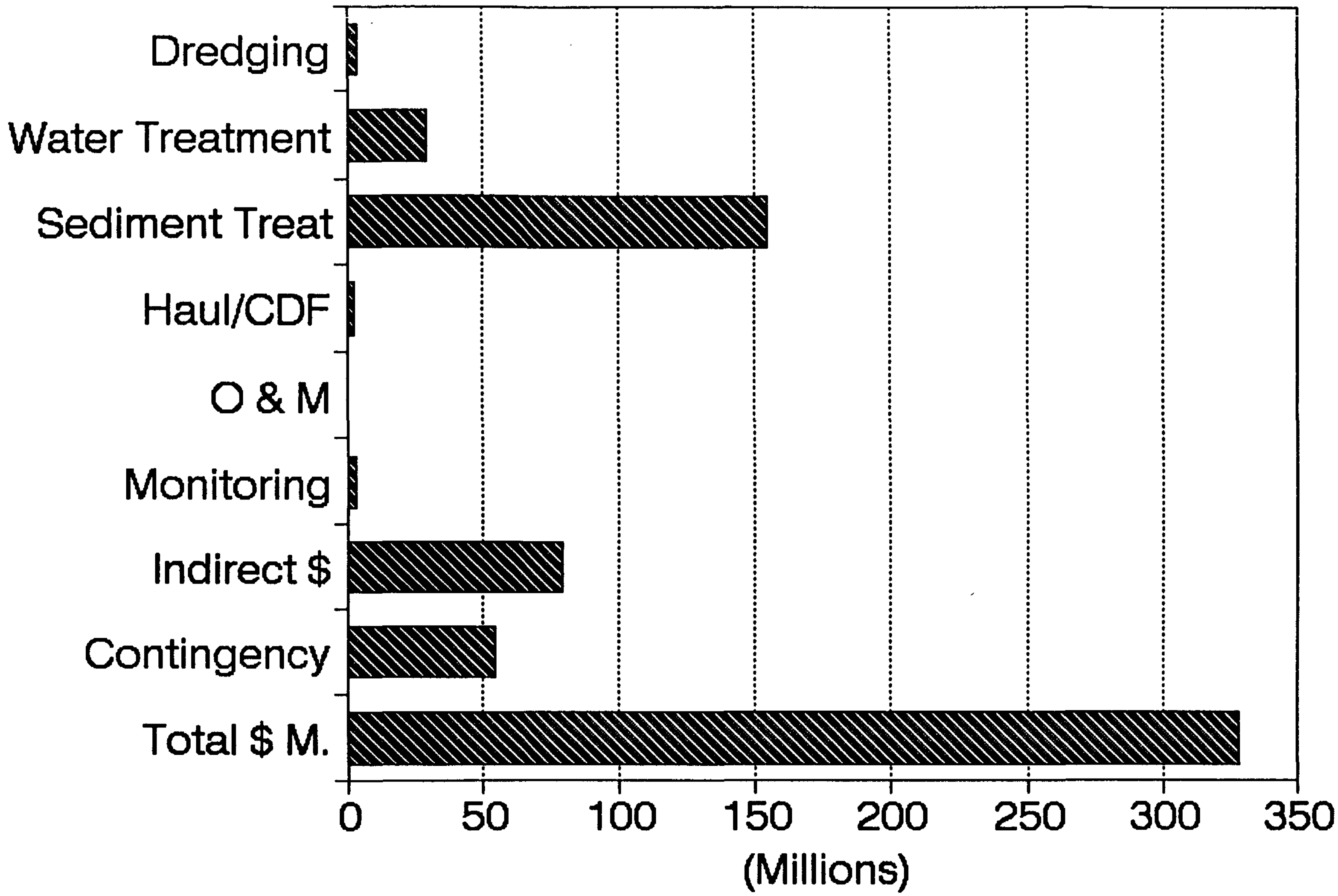


Figure 7-41

Cost Breakdown EST-6
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

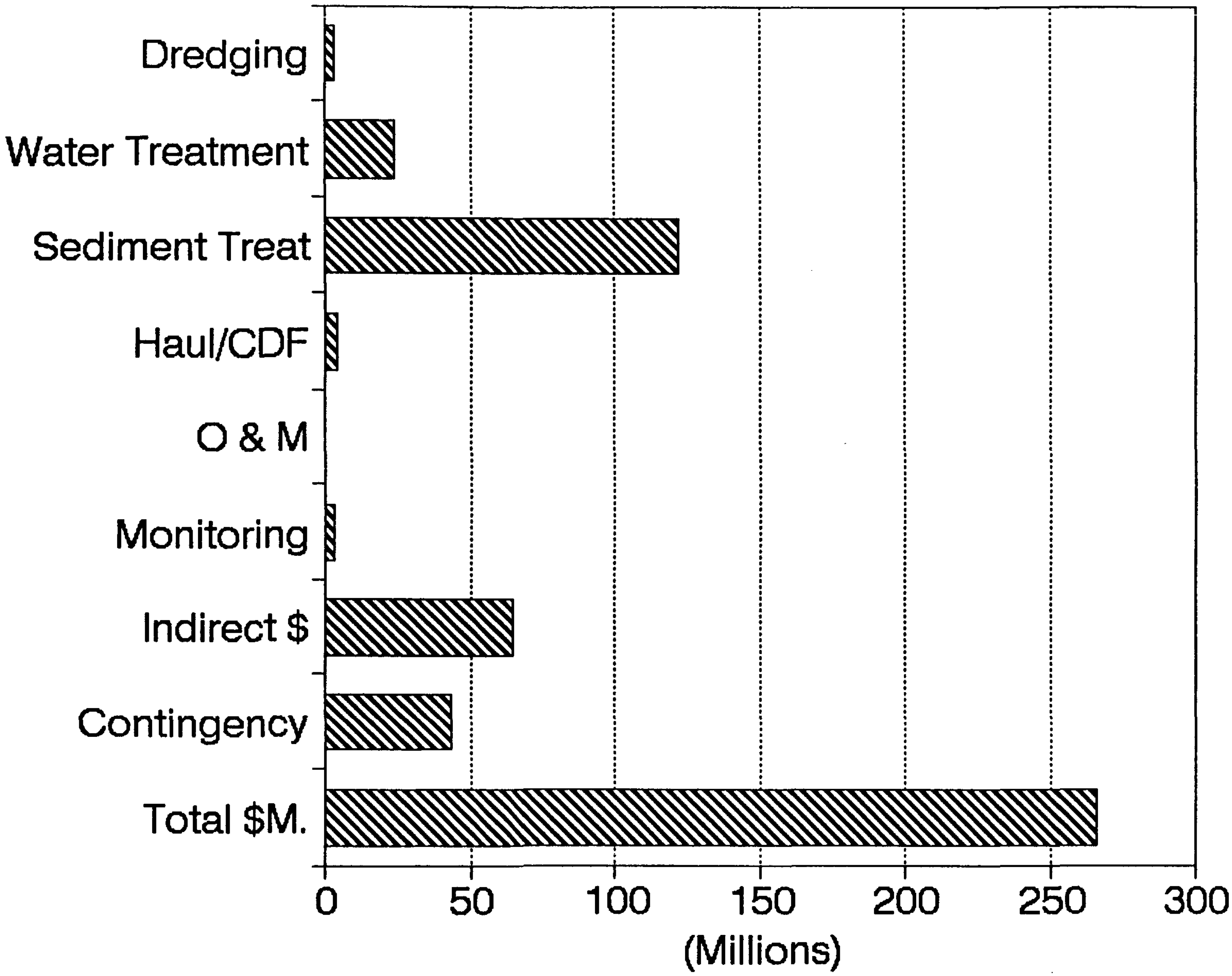


Figure 7-42

Cost Breakdown LHB-6
Estuary and Lower Harbor and Bay

Feasibility Study
New Bedford Harbor

Material transport costs for this alternative involve hauling the solidified ash to the CDFs for disposal. Distance to the CDFs is considered, as well as time required to complete each trip.

Health and safety costs, where not included as part of a line item within a given component, were added as other direct costs. For this alternative, Level D health and safety factors were added to the water treatment and material transport components at 5 percent of the overall cost of that item.

Other costs have also been considered in the total cost of implementing this alternative. Legal, administrative, and permitting costs are anticipated to add an additional 6 percent of the total capital and O&M costs. Engineering and services during remediation are anticipated to cost an additional 10 percent each. The turnkey contractor is anticipated to receive an additional 15 percent of the cost. Finally, a 20 percent contingency was added to the subtotal of these items to derive the final cost per alternative. The indirect costs and contingencies are based on standard engineering practices using undeveloped design conditions.

If it is determined that the PCB-contaminated sediment in the wetlands will need to be removed and new wetland habitats created, an additional cost, estimated to be $10 million, would be incurred. This cost includes dredging 139,000 cy of sediment and planning, construction, and propagation of new wetland habitats along the eastern shoreline of the estuary. The cost does not include any additional costs associated with material handling, CDF construction, dewatering and water treatment, or sediment treatment; however, the additional volume of sediment could significantly increase these costs.

A sensitivity analysis was conducted to determine which factors may significantly change the overall costs. For these alternatives, incineration is by far the most costly component. The unit cost used to estimate the costs of Alternatives EST-6 and LHB-6 was $340/cy of sediment. Because the sediment would retain a significant amount of water even after mechanical dewatering, and is expected to have low heat value, auxiliary fuels will need to be used to achieve high enough temperatures in the rotary kiln. This could cause the cost of incineration to increase significantly, although the amount cannot currently be estimated. Therefore, an increase of approximately 20 percent ($400/cy) was used in the cost model to show the effect on the total cost of the alternatives. For Alternative EST-6, this yields a 13 percent increase in total cost (from $328 million to $371 million). Similarly, for Alternative LHB-6, the total cost increases 13 percent, from $266 million to $300 million. Tables 7-23 and 7-24 illustrate the effects of these changes.

TABLE 7-23
SENSITIVITY ANALYSIS: ALTERNATIVE EST-6
DREDGE/INCINERATE/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)
DIRECT COSTS		
A. Dredging	$5,098,000	$5,098,000
B. Dewater/Water Treatment	$35,973,000	$35,973,000
C. Sediment Treatment	$191,583,000	$223,250,000
D. Material Hauling	$726,000	$726,000
E. CDF Construction	$2,771,000	$2,771,000
TOTAL DIRECT COSTS	$236,151,000	$267,818,000
TOTAL INDIRECT COSTS	$98,657,000	$111,641,000
CONTINGENCY	$66,962,000	$75,892,000
TOTAL CAPITAL COSTS (present worth)	$324,591,000	$367,879,000
O&M/MONITORING (present worth)	$3,575,000	$3,575,000
TOTAL COST (present worth)	$328,166,000	$371,454,000

1. Increase incineration costs to $400/cy (from $340/cy)

TABLE 7-24
SENSITIVITY ANALYSIS: ALTERNATIVE LHB-6
DREDGE/INCINERATE/DISPOSE
NEW BEDFORD HARBOR

ACTIVITY	BASELINE COST	COST (1)
DIRECT COSTS		
A. Dredging	$3,846,000	$3,846,000
B. Dewater/Water Treatment	$28,346,000	$28,346,000
C. Sediment Treatment	$144,528,000	$168,417,000
D. Material Hauling	$547,000	$547,000
E. CDF Construction	$4,833,000	$4,833,000
TOTAL DIRECT COSTS	$182,100,000	$205,989,000
TOTAL INDIRECT COSTS	$76,106,000	$85,900,000
CONTINGENCY	$51,641,000	$58,378,000
TOTAL CAPITAL COSTS (present worth)	$262,115,000	$296,308,000
O&M/MONITORING (present worth)	$3,694,000	$3,694,000
TOTAL COST (present worth)	$265,809,000	$300,002,000

1. Increase incineration costs to $400/cy (from $340/cy)

7.7.7 Compliance with ARARs

Compliance with chemical-specific ARARs pertaining to surface water and aquatic biota is discussed in Subsection 7.4.7. Incinerator air emissions would be subject to federal National Air Quality Standards (40 CFR 40) and Massachusetts Air Quality Regulations (310 CMR 6.00-8.00). Under these requirements, air emissions would need to be treated by BACT. Remedial actions should not result in impacts that degrade existing air quality.

Location-specific ARARs applicable to the wetlands and floodplains of the estuary and the lower harbor/bay are discussed in Subsection 7.4.7.

Action-specific ARARs triggered by dredging, disposal, and dewatering of contaminated sediments are identified in Subsection 7.4.7. The actions discussed as necessary to comply with those ARARs would apply to this alternative as well.

TSCA regulations would be appropriate to the design and performance requirements of the incineration facility (40 CFR 761.70). Under TSCA, test burns are required before full-scale operation. Upon EPA approval of the incinerator, operation must be conducted in compliance with technical standards outlined in TSCA, including a 99.9999 percent DRE.

Incinerated sediments would undergo TCLP analysis. Material failing TCLP maximum concentration would be subject to RCRA Massachusetts Hazardous Waste Regulations. These ARARs are discussed in detail in Subsection 7.5.7.

All site activities, including monitoring, will be carried out pursuant to OSHA standards (29 CFR 1904, 1910, and 1926) and Massachusetts Right-to-Know regulations (see Subsection 4.2.2.3).

7.7.8 Overall Protection of Public Health and the Environment

The removal of PCBs from the estuary and the lower harbor/bay and subsequent destruction by incineration would permanently reduce the mobility, toxicity, and volume of this source area of PCBs. Public health and environmental risks directly associated with the New Bedford Harbor site would be significantly reduced.

8.0 COMPARISON OF REMEDIAL ALTERNATIVES

A comparative analysis was conducted to evaluate the performance of each alternative relative to each evaluation criterion. The purpose of this comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another so that EPA can identify key trade-offs to facilitate its Selection of Remedy process. The comparative analysis, which summarizes the detailed evaluation of alternatives, is presented for each criterion in the following subsections.

8.1 Short-term Effectiveness

Short-term effectiveness refers to the alternative's effect on public health and the environment during implementation of the remedial alternative. Alternatives EST-1 and LHB-1 would present the least risk to the community, workers, and environment during implementation because the contaminated sediment would not be disturbed.

Alternatives EST-2 and LHB-2 would also present limited risks to public health. There would be little effect on the community during implementation. The only opportunity for exposure during remedial activities would occur during geotextile placement and anchoring, because the sediment would remain in place. Sediment resuspension during cap construction would be monitored to minimize environmental impacts.

The remaining alternatives involve removal of the sediment. Procedures have been developed and tested by USACE to minimize environmental impacts due to sediment resuspension. Protective clothing will be worn by workers to prevent dermal contact during dredging and handling, and air quality controls will be utilized to minimize community impacts.

The treatment technologies proposed as components of Alternatives EST-4, LHB-4, EST-5, EST-6, and LHB-6 are closed-system processes. Consequently, there is little risk associated with these treatment options. Incineration (as an auxiliary treatment for the concentrated PCB fraction in Alternatives EST-5 and LHB-5, and as a principal treatment in Alternatives EST-6 and LHB-6) has minimal risks provided operations are carefully controlled. Incinerator operations, particularly emissions, will be closely monitored.

8.2 Long-term Effectiveness and Permanence

The long-term effectiveness and permanence criterion addresses the remaining risk after the site has been remediated. The no-action and containment alternatives (i.e., Alternatives EST-1, LHB-1, EST-2, LHB-2, EST-3, and LHB-3) provide the least reduction in risk. Under the no-action alternative, the sediment will continue to act as a significant source of PCB contamination for the New Bedford Harbor system (see Subsection 2.3), even after 10 years. Average bed sediment PCB concentrations in the estuary would remain high. Water column PCB concentrations in the estuary would remain well above the AWQC. A direct contact risk to the public remains, because the sediment remains in situ. The containment alternatives (i.e., capping or disposal in CDF/CAD facilities) reduce the flux of PCBs into the water column and prevent contact exposure (unless the cap or CDF is breached); however, no permanent reduction in risk is achieved for these alternatives.

The four alternatives remaining that involve removal and treatment (i.e., Alternatives EST-5, LHB-5, EST-6, and LHB-6) offer the greatest degree of effectiveness in the long term. The solvent extraction alternatives, although not proven at full-scale, are expected to be effective in removing PCB contamination from the sediment. The alternatives include components for the management of residuals (as do Alternatives EST-6 and LHB-6). Incineration and solidification are demonstrated technologies for organics and metals, respectively. No residual risk associated with the dredged sediment is expected following implementation of these alternatives.

A residual risk remains after implementation for any of the alternatives evaluated, due to the 10-ppm TCL chosen for remedial action. Because of this residual risk, all the alternatives require institutional controls, a long-term monitoring program, and five-year reviews. The long-term effectiveness of each alternative depends on the reliability of these programs.

8.3 Reduction in Mobility, Toxicity, and Volume

This criterion evaluates the alternative's ability to permanently and significantly reduce the contaminants' mobility, toxicity, or volume. Alternatives EST-1 and LHB-1 do not address this criterion because no remedial action is employed. Alternatives EST-2, LHB-2, EST-3, and LHB-3 do not reduce the mobility, toxicity, or volume of the PCBs or metals, but may reduce the potential for migration into the water column. The volume of contaminanted media may increase under Alternatives EST-2 and LHB-2, if the PCBs migrate into the cap material.

Alternatives EST-4 and LHB-4 reduce the mobility of the PCBs and metals through chemical stabilization, while increasing the volume of material to be disposed of. Solvent extraction (Alternatives EST-5 and LHB-5) is expected to reduce the mobility, toxicity, and volume of the PCBs through removal and thermal destruction of the organic fraction. Alternatives EST-6 and LHB-6 will provide the most reliable and proven method of reduction in mobility, toxicity, and volume of PCBs in the sediment. Further reduction in the mobility of the metals is achieved by solidifying the residual after treatment.

8.4 Implementability

The implementability of an alternative includes the technical and administrative feasibility of implementing the alternative, as well as the availability of the technology. Of the alternatives developed for the estuary and the lower harbor/bay, Alternatives EST-1 and LHB-1 would be the simplest alternatives to implement because they involve minimal construction and no treatment activities. USACE considers Alternatives EST-2 and LHB-2 technically feasible to implement, and materials are available in the New Bedford area to construct the cap.

All removal alternatives would require dredging, CDF construction, and water treatment facilities. Of these, Alternatives EST-3 and LHB-3 are the most basic and easy to implement, except that they require many CDFs to contain the dredged sediments. Alternatives EST-4, LHB-4, EST-6, and LHB-6 would also be fairly easy to implement because solidification and incineration equipment is readily available with documented success.

Alternatives EST-5 and LHB-5 are expected to be the most difficult to implement. Specialized solvent extraction equipment would need to be mobilized to the site and tested before full-scale operation. Because this is an innovative technology and equipment is limited in supply, the equipment would need to be scheduled or constructed before mobilization.

All 12 alternatives are expected to be administratively feasible, because no off-site construction activities are planned.

8.5 Cost

Costs for the 12 alternatives and sensitivity to various assumptions are discussed in Section 7.0. The present worth of each alternative is summarized in ascending order as follows:

ALTERNATIVE	DESCRIPTION	EST COST	LHB Cost
EST-1/LHB-1	No Action	$ 4,092,000	$ 3,386,000
EST-2/LHB-2	Capping	46,121,000	59,792,000
EST-3/LHB-3	Dredge/Dispose	77,434,000	71,766,000
EST-3d/LHB-3d	Dredge/Dewater/ Dispose	86,240,000	77,811,000

ALTERNATIVE	DESCRIPTION	EST COST	LHB Cost
EST-4/LHB-4	Dredge/Solidify/ Dispose	164,800,000	135,525,000
EST-5/LHB-5	Dredge/Solvent Extract/Dispose	262,886,000	214,524,000
EST-6/LHB-6	Dredge/Incinerate/ Dispose	328,166,000	265,809,000

Figures 8-1 and 8-2 graphically illustrate the comparative costs of the alternatives.

8.6 Compliance with ARARs

This criterion evaluates the alternatives on the basis of how they will comply with ARARs. The no-action alternatives will not comply with any chemical-specific ARARs, and do not trigger any location- or action-specific ARARs by definition. The other alternatives will comply with all chemical-, location-, and action-specific ARARs except the AWQC, because removal of the PCB-contaminated sediment from the estuary and harbor to the 10-ppm TCL is not expected to immediately lower PCB concentrations in the water column to below the AWQC standard.

8.7 Overall Protection of Public Health and the Environment

Overall protection of public health and the environment is a primary, or threshold, criteria that must be met by any alternative in order for it to be eligible for selection. All the alternatives discussed in this FS, except for the no-action alternative (EST-1/LHB-1), provide some additional level of protection to public health and the environment over baseline conditions.

A range of alternatives was developed for the estuary and the lower harbor/bay, including no-action, containment, and removal with various treatment actions. Alternative EST-6/LHB-6 includes removal and permanent destruction of the PCB-contaminated sediment. As such, this alternative will result in a permanent reduction in baseline risks. Other alternatives include removal action with various treatment and disposal options. While these alternatives provide an adequate level of protection to public health and the environment by limiting contaminant exposure, they do not provide for permanent destruction of PCBs.

As such, there is some residual risk associated with the treated, untreated, or solidified sediments. The final alternative, EST-2/LHB-2, involves containing PCB-contaminated sediments.

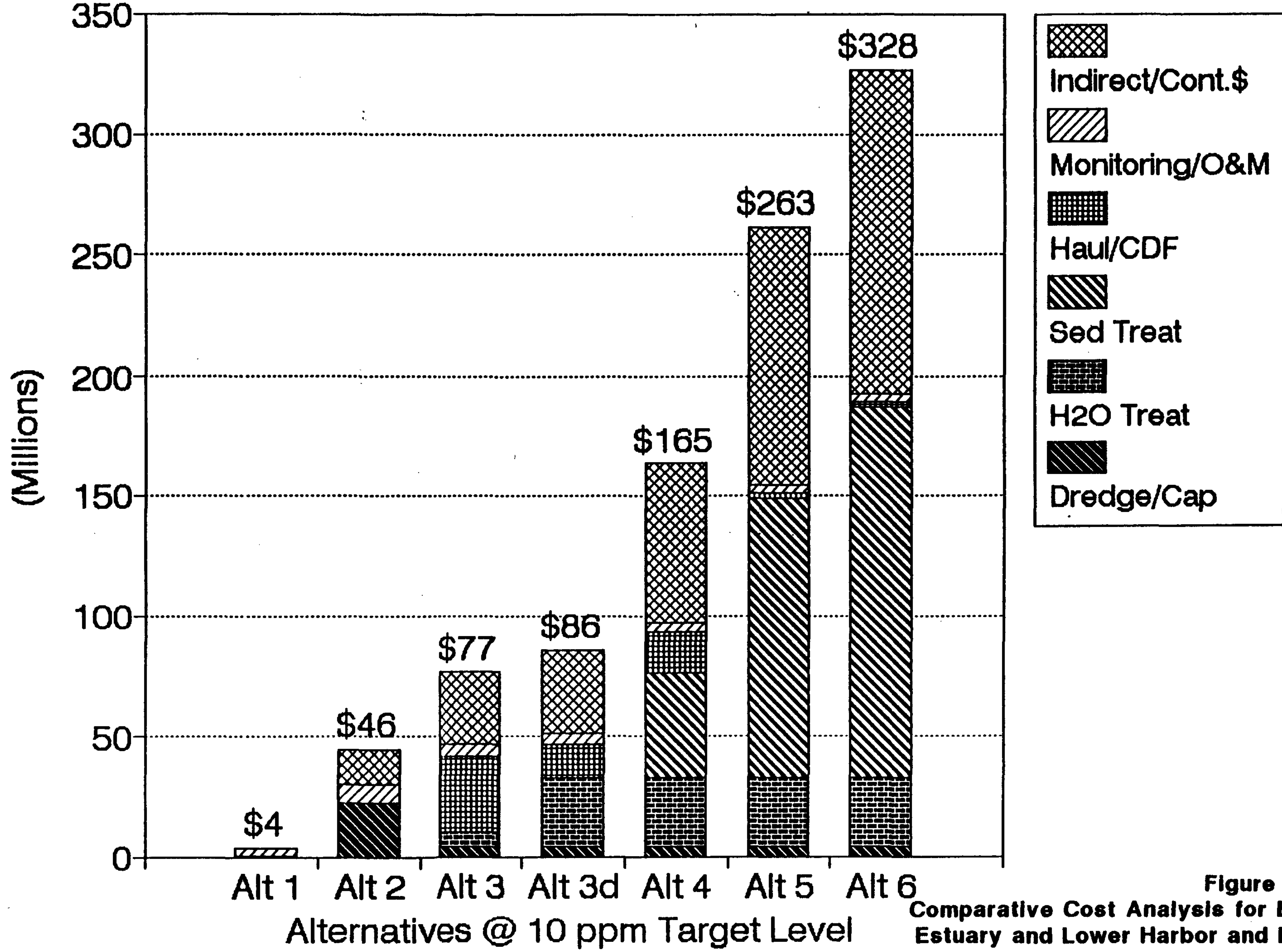


Figure 8-1
Comparative Cost Analysis for EST
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

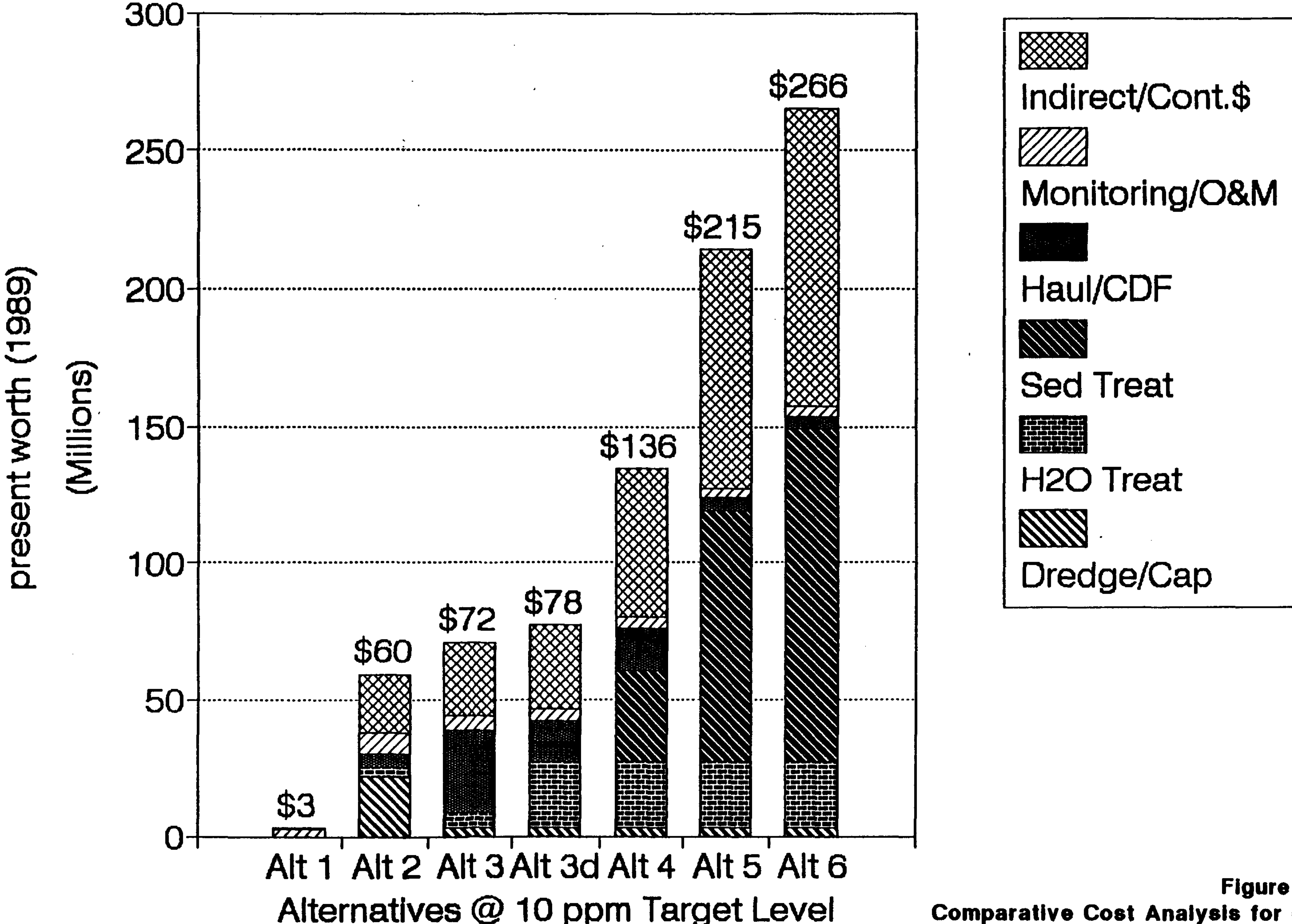


Figure 8-2
Comparative Cost Analysis for LHB Estuary and Lower Harbor and Bay Feasibility Study New Bedford Harbor

This alternative effectively limits contaminant exposure and therefore results in a reduction of public health and environmental risk. However, the future contaminant exposure and subsequent risk to public health and the environment will result if the cap material fails. The permanence and integrity of the cap material cannot be determined at this time.

Table 8-1 summerizes the comparative analysis of alternatives for this site.

TABLE 8-1
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-1 & LHB-1 NO-ACTION	ALTERNATIVES EST-2 & LHB-2 CAPPING	ALTERNATIVES EST-3 & LHB-3 DISPOSAL	ALTERNATIVES EST-4 & LHB-4 SOLIDIFICATION/DISPOSAL
Reduction of Toxicity, Mobility, or Volume	No reduction in toxicity, mobility, or volume because no remedial action is employed.	No reduction in mobility or toxicity. May cause an increase in volume of contaminated sediment.	Reduction in mobility or toxicity. Volume will increase if the sediment is not dewatered prior to disposal.	Reduction in mobility of the contaminants. No reduction in toxicity. Volume increased by solidification.
Short-term Effectiveness				
o Time until Protection is Achieved	No reduction in public health or environmental risk is expected.	Reduction in public health risk should occur immediately after cap placement and consolidation. Time required to achieve protection of biota depends on benthic recolonization of new cap surface.	Reduction in public health risk should occur immediately after sediment removal. Significant reduction in water column concentrations and subsequent reduction biota.	Same as Alternatives EST-3 and LHB-3.
o Protection of Community during Remedial Actions	No impact to community during remedial action.	No impact to community during remedial action.	Dredge controls and air quality controls will minimize community impacts.	Same as Alternatives EST-3 and LHB-3.
o Protection of Workers during Remedial Actions	Minimal risk to workers during fence/sign installation.	Minimal risk to workers during cap placement.	Protection required against dermal contact with dredged sediments.	Protection required against dermal contact with dredged sediments and fugitive dust from dewatered sediments and solidification process.
o Environmental Impacts	No significant adverse environmental impact from fence installation.	Destruction of benthic community will occur. Sediment resuspension expected during cap construction.	Minimal environmental impact expected from dredging or construction.	Same as Alternatives EST-3 and LHB-3.
Long-term Effectiveness				
o Magnitude of Residual Risk	Significant risks remain for public health associated with direct contact of surface soils. Environmental risks would continue unmitigated.	Potential risks remain because contaminated sediments remain in place.	Slight risks remain because the contaminants are not treated.	After sediments have been solidified and disposed of on-site, there will be minimal residual risk.
o Adequacy of Controls	No direct engineering controls; fence subject to vandalism; annual monitoring and repair required.	Annual monitoring and maintenance is required. Channel maintenance and shoreline construction will be limited. Controls to limit access to the estuary may be difficult to enforce.	Confined disposal facility construction is a proven technology; annual monitoring and maintenance is required.	Solidification and confined disposal facility construction are proven technologies; annual monitoring and maintenance of the CDFs is required.

TABLE 8-1
(continued)
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-5 & LHB-5 SOLVENT EXTRACTION	ALTERNATIVES EST-6 & LHB-6 INCINERATION
Reduction of Toxicity, Mobility, or Volume	Reduction in toxicity and mobility of PCB sediments. Volume will increase if solidification is employed to prevent metal leaching.	Reduction in toxicity and mobility of PCB sediments. Volume also reduced unless ash is solidified to prevent metals leaching.
Short-term Effectiveness		
o Time until Protection is Achieved	Same as Alternatives EST-3 and LHB-3.	Same as Alternatives EST-3 and LHB-3.
o Protection of Community during Remedial Actions	Same as Alternatives EST-3 and LHB-3.	Same as Alternatives EST-3 and LHB-3.
o Protection of Workers during Remedial Actions	Protection required against dermal contact with dredged sediments and fugitive dust from dewatered and treated sediments.	Protection required against dermal contact with dredged sediments and fugitive dust from dewatered sediments and ash.
o Environmental Impacts	Same as Alternatives EST-3 and LHB-3.	Same as Alternatives EST-3 and LHB-3.
Long-term Effectiveness		
o Magnitude of Residual Risk	After sediments have been treated and solidified (if needed), there will be minimal residual risk.	After sediments have been incinerated and the ash solidified (if needed), there will be minimal risk associated with the treated sediments.
o Adequacy of Controls	Treatment by solvent extraction is expected to produce a treated sediment that will not need long-term control.	Incineration is a proven technology; no long-term management of treatment residuals required.

TABLE 8-1
(continued)
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-1 & LHB-1 NO-ACTION	ALTERNATIVES EST-2 & LHB-2 CAPPING	ALTERNATIVES EST-3 & LHB-3 DISPOSAL	ALTERNATIVES EST-4 & LHB-4 SOLIDIFICATION/DISPOSAL
o Reliability of Controls	Sole reliance on fence and institutional controls to prevent exposure; high level of residual risk.	Low reliability due to potential for cap failure or disturbance.	Likelihood of CDF failure is small as long as O&M is performed. Leachate monitoring is required.	Likelihood of CDF failure is small as long as O&M is performed.
Implementation				
o Technical Feasibility	Fence/signs are easily constructed; environmental monitoring well-proven.	Technology exists to effectively cap the estuary.	CDFs easy to implement; dewatering proven during bench- and pilot-scale tests.	CDFs easy to implement; dewatering and solidification of sediments proven during bench- and pilot-scale tests.
o Administrative Feasibility	No off-site construction; therefore, no permits required.	Same as Alternatives EST-1 and LHB-1.	Same as Alternatives EST-1 and LHB-1.	Same as Alternatives EST-1 and LHB-1.
o Availability of Services and Materials	Services and materials locally available.	Services and materials readily available.	Dredge, dewatering, and CDF construction services available in the eastern U.S.	Dredge, dewatering, and solidification services available in the eastern U.S.
Cost				
Present Worth Cost	$4,092,000/$3,386,000	$46,121,000/$59,792,000	$77,434,000/$71,766,000 $86,240,000/$77,811,000 (dewatered)	$164,800,000/$135,525,000
Compliance with ARARs/TBCs				
o Compliance with ARARs	AWQC will not be attained.	AWQC will not be attained. All other ARARs will be met.	Same as Alternatives EST-2 and LHB-2.	Same as Alternatives EST-2 and LHB-2.

COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-5 & LHB-5 SOLVENT EXTRACTION	ALTERNATIVES EST-6 & LHB-6 INCINERATION
o Reliability of Controls	Remedy will be highly reliable due to removal of sediment causing risk.	Same as Alternatives EST-5 and LHB-5.
Implementation		
o Technical Feasibility	Solvent extraction would require special equipment and operators; treated residuals would require testing to verify treatment effectiveness; technology has been bench-tested on Hot Spot sediments.	Incineration would require special equipment and operators; treated residuals would require testing to verify treatment effectiveness; technology has been demonstrated at other sites.
o Administrative Feasibility	Same as Alternatives EST-1 and LHB-1.	Same as Alternatives EST-1 and LHB-1.
o Availability of Services and Materials	Solvent extraction equipment available from vendors but not readily. Equipment construction and pilot-scale tests may be required.	Dredge, dewatering, and mobile incinerator equipment and operators needed; services available in the eastern U.S.
Cost		
o Present Worth Cost	$262,886,000/$214,524,000	$328,166,000/$265,809,000
Compliance with ARARs/TBCs		
o Compliance with ARARs	AWQCs will not be attained. Solvent extraction will need to achieve equivalent performance standards.	Same as Alternatives EST-2 and LHB-2.

TABLE 8-1
(continued)
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-1 & LHB-1 NO-ACTION	ALTERNATIVES EST-2 & LHB-2 CAPPING	ALTERNATIVES EST-3 & LHB-3 DISPOSAL	ALTERNATIVES EST-4 & LHB-4 SOLIDIFICATION/DISPOSAL
o Compliance with Criteria, Advisories, and Guidance	Does not meet FDA level for PCBs in fish and shellfish.	Not expected to achieve FDA level for PCBs in fish and shellfish.	Same as Alternatives EST-2 and LHB-2.	Same as Alternatives EST-2 and LHB-2.
Overall Protection of Public Health and the Environment				
o How Risks are Reduced, Eliminated, or Controlled	Risks to public health are reduced by restricting site access, environmental risks are not mitigated.	Risks to public health and the environment are reduced by minimizing contact with contaminated sediments.	Risks to public health and the environment are significantly reduced by the removal of the sediments.	Risks to public health and the environment are significantly reduced by the removal and treatment of the sediments.

TABLE 8-1
(continued)
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-5 & LHB-5 SOLVENT EXTRACTION	ALTERNATIVES EST-6 & LHB-6 INCINERATION
o Compliance with Criteria, Advisories, and Guidance	Same as Alternatives EST-2 and LHB-2.	Same as Alternatives EST-2 and LHB-2.
Overall Protection of Public Health and the Environment		
o How Risks are Reduced, Eliminated, or Controlled	Same as Alternatives EST-4 and LHB-4.	Same as Alternatives EST-4 and LHB-4.

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

AAL	Allowable Ambient Level
AET	Apparent Effects Threshold
ARARs	applicable or relevant and appropriate requirements
ASA	Applied Science Associates, Inc.
AWQC	ambient water quality criteria
BACT	Best Available Control Technology
BCF	bioconcentration factor
BOS	Battelle Ocean Sciences
CAD	confined aquatic disposal
CDC	Centers for Disease Control
CDF	confined disposal facility
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CI	confidence interval
cm	centimeters
cm/sec	centimeters per second
CSO	combined sewer overflow
CWA	Clean Water Act
cy	cubic yards
CZM	Coastal Zone Management (Massachusetts)
DRE	destruction and removal efficiency
EFS	Engineering Feasibility Study
EP	Equilibrium Partitioning; Extraction Procedure
EPA	U.S. Environmental Protection Agency
ERL	Environmental Research Laboratory (EPA)
FDA	U.S. Food and Drug Administration
FFDCA	Federal Food, Drug, and Cosmetic Act
FS	Feasibility Study
gpd	gallons per day
g/sec	grams per second
HI	Hazard Index
k_d	partition coefficient
kg	kilograms
kg/yr	kilograms per year
K_{ow}	octanol-water partition coefficient
KPEG	potassium hydroxide/polyethylene glycol
MADEP	Massachusetts Department of Environmental Protection
MATC	Maximum Acceptable Toxicant Concentration
MCL	Maximum Contaminant Level
MCP	Massachusetts Contingency Plan
m/day	meters per day

<u>GLOSSARY OF ACRONYMS AND ABBREVIATIONS</u>
(continued)

MDPH	Massachusetts Department of Public Health
mg	milligrams
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MLW	mean low water
m/sec	meters per second
NCP	National Contingency Plan
NEPA	National Environmental Protection Act
ng/cm	nanograms per cubic meter
ng/L	nanograms per liter
NOI	Notice of Intent
NPL	National Priorities List
NUS	NUS Corporation
OHM	O.H. Materials Corporation
O&M	operation and maintenance
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response (EPA)
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEL	permissible exposure level
PNL	Pacific Northwest Laboratories (Battelle)
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
PRP	potentially responsible party
psi	pounds per square inch
RAMP	Remedial Action Master Plan
RCC	Resource Conservation Company
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SITE	Superfund Innovative Technology Evaluation
SLC	Screening Level Concentration
SQC	Sediment Quality Criteria
SQT	Sediment Quality Triad
S/S	solidification/stabilization
SSLC	Species Screening Level Concentration
STC	Silicate Technology Corporation
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCL	Target Clean-up Level
TCLP	Toxicity Characteristic Leaching Procedure
TEA	triethylamine
TKF	toxicokinetic factor
TOC	total organic carbon
TSCA	Toxic Substances Control Act

GLOSSARY OF ACRONYMS AND ABBREVIATIONS
(continued)

TSM	total suspended material
TSS	total suspended solids
TWA	time-weighted average
UCS	unconfined compressive strength
ug/g	micrograms per gram
ug/goc	micrograms per grams, organic carbon normalized
ug/kg	micrograms per kilogram
ug/L	micrograms per liter
USACE	U.S. Army Corps of Engineers
UV	ultraviolet
WES	Waterways Experiment Station
WHOI	Woods Hole Oceanographic Institution

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